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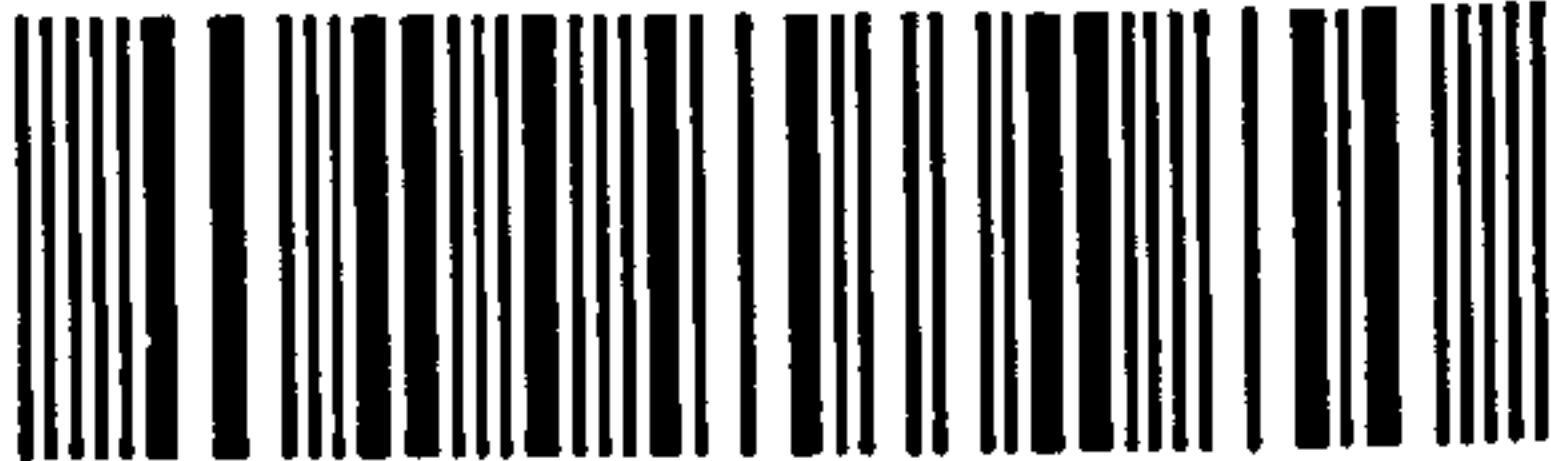
# **Team Approaches To Developing Innovative Products And Processes**

Sally Patricia Caird

Ph.D. 1996



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# Team Approaches To Developing Innovative Products And Processes

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This thesis is submitted for the Degree of Doctor of Philosophy.

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# Contents

- Chapter 1 Introduction ..... 1
- Chapter 2 Overview Of The Theoretical Literature ..... 9
  - 2.1. Value Of Team Approaches .....9
  - 2.2. Co-ordination Of Innovation .....17
    - 2.2.1. Models Of Innovation.....18
    - 2.2.2. Management Of Innovation .....20
      - 2.2.2.1. Sequential Approach .....20
      - 2.2.2.2. Iterative Approach.....22
      - 2.2.2.3. Multi-Departmental Approach .....23
    - 2.2.3. The Team In Organisational Theory.....25
      - 2.2.3.1. Organisation Of Innovation .....26
      - 2.2.3.2. New Organisational Approaches To The Management of Innovation .....28
    - 2.2.4. Implications Of Innovation Models For Team Use .....32
    - 2.2.5. Changing Management Throughout The Innovation Process.....33
    - 2.2.6. Hypothesis .....36
  - 2.3. Appropriateness Of Multi-functional Teams To Developing Projects Of Varying Innovation .....36
    - 2.3.1. Are Different Teams Appropriate To Radical And Incremental Innovations? .....39
    - 2.3.2. Are Multi-Functional Teams More Appropriate To Developing Radical Innovations Than Incremental Innovations? .....42
    - 2.3.3. Hypothesis .....44
  - 2.4. Innovation Management And Firm Size .....46
    - 2.4.1. Hypothesis .....53
  - 2.5. Impact Of Complex Team Processes On Effectiveness .....54
    - 2.5.1. Contribution Of Group Theories .....55
    - 2.5.2. Group Processes And Effectiveness .....58
      - 2.5.2.1. Membership Variables .....59
      - 2.5.2.2. Interaction Variables .....60
      - 2.5.2.3. Task Variables.....62
      - 2.5.2.4. Environment Variables.....62
    - 2.5.3. Impacts Of Multi-Functional Membership In Teams .....63
    - 2.5.4. Hypothesis .....64
  - 2.6. Importance Of Team Approaches For Innovation Success.....65
    - 2.6.1. Hypothesis .....70
- Chapter 3 The Environment Industry And Markets For Technological Innovation..... 71
  - 3.1. Introduction .....71
  - 3.2. The Nature And Structure Of The Industry .....72
  - 3.3. The UK And EU Context .....75
  - 3.4. Opportunities For Environmental Innovation .....81
  - 3.5. Conclusions .....84



<b>Chapter 4 Research Methodology.....</b>	<b>86</b>
4.1. Introduction .....	86
4.2. Hypotheses .....	86
4.3. Rationale For Case Study Approach.....	87
4.4. Sample .....	88
4.4.1. Sample Selection .....	89
4.4.2. Sample Overview .....	91
4.5. Methods Of Investigation .....	94
4.6. Operational Definitions .....	96
4.7. Analysis Methods .....	97
4.8. Measurement Issues.....	99
4.9. Generalising From Findings .....	104
<b>Chapter 5 Company Teams.....</b>	<b>105</b>
5.1. Introduction .....	105
5.2. Team Use In Organisations.....	105
5.3. Definition Of Teams .....	107
5.4. Perception Of Team Boundary .....	109
5.5. Origins Of Teams .....	115
5.5.1. First Time Emergence Of Teams.....	116
5.5.2. Organisational Changeover To Team Approaches .....	116
5.6. The Organisational Fate Of Teams .....	118
5.7. Non-Use Of Teams By Companies.....	122
5.8. Summary.....	126
<b>Chapter 6 Multi-Functional, Multi-Disciplinary And Single-Disciplinary Team Approaches.....</b>	<b>129</b>
6.1. Introduction .....	129
6.2. Multi-Functional Team Approaches .....	132
6.2.1. The Co-ordinator's Expertise .....	136
6.2.2. The Source Of Multi-Functionality .....	137
6.2.3. The Nature And Timing Of Staff Interaction. ....	139
6.2.4. Involvement Of Several Teams .....	146
6.3. Multi-Disciplinary Team Approaches .....	148
6.4. Single-Disciplinary Team Approaches .....	153
6.5. Summary.....	158
<b>Chapter 7 Influences Of Firm Size And Level Of Project Innovation On Team Approaches.....</b>	<b>161</b>
7.1. Introduction .....	161
7.2. Associations Between Firm Size And Team Approaches.....	161
7.3. Associations Between Level Of Project Innovation And Team Approaches.....	164
7.3.1. Level Of Project Innovation And Requirements For New Organisational Structures .....	164
7.3.2. Inter-Company Analysis .....	165
7.3.3. Intra-Company Differences .....	167
7.3.3.1. Developing Innovative And Routine Projects .....	169
7.3.3.2. Developing Major And Minor Innovations .....	170
7.4 Summary.....	173



<b>Chapter 8 Evaluation Of Team Effectiveness.....</b>	<b>173</b>
8.1. Introduction .....	173
8.2. Team Operations .....	173
8.3. Associations Between Team Approaches And Team Problems .....	177
8.3.1. Significant Differences In The Problems Of Teams .....	180
8.4. Positive Aspects Of Team Operations .....	181
8.4.1. Significant Differences In The Positive Aspects Of Teams.....	182
8.5. Effectiveness And Satisfaction With Team Operations .....	184
8.5.1. Team Member Perceptions Of Satisfaction .....	184
8.5.2. Team Member Perceptions Of Effectiveness .....	185
8.5.3. Team Effectiveness And Problems With Team Operations .....	186
8.5.3.1. Problems Of Effective Multi-Functional Teams And Multi-Functional Teams With Mixed Ratings .....	188
8.5.4. Team Effectiveness And Positive Aspects Of Team Operations.....	190
8.5.4.1. Positive Team Operations In Effective Multi-Functional Teams And Multi- Functional Teams With Mixed Ratings.....	191
8.5.5. Comparisons Of Team Effectiveness And Satisfaction .....	192
8.6. The Value Of Multi-Functional Team Approaches .....	194
8.6.1. Better Team Practices.....	203
8.7. Summary.....	208
<b>Chapter 9 The Importance Of Team Approaches For Success .....</b>	<b>214</b>
9.1. Introduction .....	214
9.2. Classification Of Project Success Outcomes .....	214
9.3. Were There Direct Relationships Between Team Approaches And Success Outcomes?.....	220
9.4. Were There Direct Relationships Between Team Effectiveness And Success Outcomes?.....	222
9.5. The Impact Of The Team On Project Success.....	224
9.6. The Team's Influence On Success.....	226
9.6.1. Significance Of Team Effectiveness For Commercial Success Of Client-Funded Projects	227
9.6.2. Limitations Of Effective Successful Teams.....	228
9.6.3. Significance Of Multi-Functional Teams For Commercial Success In Open Markets .....	229
9.6.4. Significance Of The Team For Projects With Moderate Commercial Success .....	233
9.6.5. Significance Of The Team For Commercially Unsuccessful Projects.....	237
9.7. Summary.....	240
<b>Chapter 10 Discussion Of Main Findings.....</b>	<b>243</b>
10.1. Introduction .....	243
10.2. Firm Size .....	243
10.3 Inter-Company Alliances .....	245
10.4. Level Of Project Innovation .....	246
10.5. Nature Of Markets .....	247
10.6. The Nature Of Organisational Teams .....	247
10.6.1. Multi-Functional, Multi-Disciplinary and Single-Disciplinary Teams .....	248
10.6.2. Non-Team Approaches.....	253
10.6.3. Evaluation of Team Approaches .....	254
10.7. Recommendations For Team Management.....	257
10.8. Impact Of Team Approaches On Innovation Success .....	259
10.9. Conclusions .....	261
<b>References .....</b>	<b>265</b>



**Appendix 1 Innovators Competing For The ‘Environment Award For Engineers’ ..... 269**  
Letter And Questionnaire.....269

**Appendix 2 Interview Questionnaire..... 273**  
SECTION 2: BACKGROUND TO THE COMPANY/DIVISION.....274  
SECTION 3: COMPANY PROJECTS .....277  
SECTION 4: APPROACH TO PRODUCT AND PROCESS DEVELOPMENT PROJECTS .....280  
SECTION 5 PROJECT MANAGEMENT.....283  
SECTION 6 SUCCESS OUTCOMES: PRODUCT PERFORMANCE, SATISFACTION AND  
COMMERCIAL SUCCESS .....288

**Appendix 3 Postal Questionnaire And Accompanying Letter ..... 296**

# Abstract

The research aimed to identify the most appropriate team approaches for co-ordinating innovative products or process developments and for enhancing their success. Case studies were conducted in 25 UK companies, focusing on environmental technology projects. Research findings emphasised the diversity of organisational team approaches which were more complex when several departments, teams or companies were involved. Team approaches were broadly classified - 'single-disciplinary', 'multi-disciplinary' or 'multi-functional' - according to members' expertise and innovation function which could be more or less integrated. The results showed that:

1. Multi-tasking to meet all innovation functions reflected small firm limitations and small firms would benefit from more formal structures. Differences between medium- and large-sized firms were minimal since teams held more specialist expertise. However, the influence of firm size on innovation success was obscured and potentially negated by inter-company alliances.
2. Few differences in the management of minor and major company innovations applied since competitive pressures led to organisational innovation in each case, including integrated team approaches, inter-company alliances and company formations.
3. Multi-functional teams were important for achieving success in open markets because of their control over appropriate expertise, even though they did not guarantee commercial success or other benefits. Surprisingly, multi-functional teams were typically rated as unsatisfactory and ineffective by members which may have implications for staff morale and retention.
4. Inter-company teams represented opportunities for team learning and organisational development because company-based assumptions about organisational behaviour, expectations about inter-company operations and fears about inter-disciplinary teamworking were challenged.
5. Integrated teams were not sufficient for achieving team effectiveness and success outcomes, although most companies regarded their team as necessary for success. Complex team and innovation development processes emphasised the importance of the co-ordinator's role in managing unclear team and organisational boundaries associated with innovative developments.
6. Although the research supports the importance of teams for innovation success, team effectiveness had a more complex influence on success in open markets than on client-funded projects because of the nature of the teams and the influence of market and technological uncertainties.



# Chapter 1 Introduction

With international competitiveness accelerated by the impact of new technologies, industry is now under greater pressure to meet the challenges for higher productivity, faster product cycles, higher quality (Maccoby, 1990) and lower costs (Takeuchi and Nonaka, 1986) in increasingly internationalised markets. As a result of these competitive pressures various initiatives have arisen, such as Design for Manufacturing (DFM) which refers to the ‘...efforts by design and manufacturing to improve the product-process fit or to increase the degree to which the product and process are designed simultaneously’ (Susman, 1992, p.4) and the Simultaneous or Concurrent Engineering initiative which refers to the organisation of product development for a quick time-to-market by optimising for the simultaneous development of product with process. Another initiative, Total Quality Management (TQM) poses some contradictions for the principle of Simultaneous Engineering, since the latter may involve resource wastage with management for a quick time-to-market, whereas the TQM movement aims to avoid resource wastage in continuous quality improvement (Durand, 1995). Despite some contradictions for management, the initiatives of TQM, DFM and Simultaneous Engineering all seek to integrate all management functions in new product development and teams are clearly a key way to achieve this integration.

An academic initiative known as the Management Of Technology (MOT) Movement has arisen since classical management theories are inadequate to handle the complexities associated with rapid technological change and intensified competition (See Souder and Sherman, 1994). Rothwell has attempted to describe the nature of innovation in the 1990’s by the ‘Fifth Generation’ model of innovation (Rothwell, 1992). He discussed the way technological change influences the management of innovation and suggested that in the 1990’s, the management of innovation is characterised by the ‘Fifth Generation’ model of innovation, where the innovation process has become largely electronified due to the impact of major new technologies, leading to increasing speed of product development (*ibid.*, 1992). The ‘Fifth Generation’ model is also called the ‘Systems Integration And Networking Model’ of innovation (SIN) because technological change has led to greater inter-company networking, alliances and integrated team-working (*ibid.*, 1992). This new paradigm replaces sequential or departmental approaches often criticised for not enhancing the cross-fertilisation of ideas resulting with slow product developments due to the poor integration of staff on projects (Twiss, 1992). Rothwell’s model is part of the academic



effort to describe and prescribe the management of innovation in the 1990's (Rothwell, 1992).

An emphasis on the value of team-working to meet the challenges of managing innovation in the 1990's emerges from both contemporary management and academic initiatives. As early as 1966, Burns and Stalker claimed that the '...task of the 20th century is organisational inventiveness' (Burns and Stalker, 1966, p.96). With the impacts of technological change and the increasing internationalisation of markets, there is a growing perception that the nature of organisation itself can provide a firm with competitive advantage; this is clear from the turnover of management fads in business process re-engineering, which have included ideas on excellent companies (Peters and Waterman, 1989), as well as several Japanese practices such as Just In Time Management, TQM and so on. While there are no universal prescriptions, multi-functional team approaches represent one of several ideas of the past 15 years on how to manage the development of technologically innovative products and processes for faster, better and cheaper results.

Recent research has suggested that teams are the key to improving the performance and competitiveness in all kinds of organisations (Ancona and Caldwell, 1987; Stewart, 1989; Kakabadse, 1991; Katzenbach and Smith, 1993). The use of teams has gained recent importance as a fundamental unit of organisational structure (Ciborra, 1993). However, research on teams has been scarce and either largely confined to laboratory groups or greater attention being given to the formal or informal aspects of organisation than to teams which are quasi-formal in structure (Jelinek and Schoonhoven, 1990).

The main aim of the present research is to enhance the research and understanding of organisational teams which work on the development of innovative products and processes. The key research question is how valuable are multi-functional team approaches for the technical and commercial outcomes of innovative products and processes of varying levels of innovation developed by environmental organisations of different sizes, operating in different market sectors. The objectives of the research are as follows:

- to describe, compare and contrast organisational team approaches to the development of innovative products and processes;
- to ascertain the influence on organisational team approaches of the level of project innovation, firm size and types of markets, both open and client-funded markets;



- to evaluate the impacts of different team approaches on project outcomes including team effectiveness, satisfaction and technical and commercial success outcomes;
- to identify the significance of the team for the success of innovative products and processes.

**Chapter 2** presents the theoretical background on the organisation and management of innovation, drawing on a literature from several discipline areas, including organisational theory, innovation management, innovation theory, firm size, organisational teams and psychological research on groups. Innovation here refers to the commercialisation of technological change (Rothwell, 1992) and the accompanying process which may include the following, not necessarily sequential, steps of idea generation, market definition, concept development, R&D, manufacturing, launch and follow-up service (Souder and Sherman, 1994).

Chapter 2 draws on the literature to formulate hypotheses on the nature and value of organisational team approaches which are adopted in different project and organisational circumstances. The key focus for the research is the multi-functional team which has been inspired by Japanese management practices. The purpose of the multi-functional team is to produce a better-quality product and speed up project development time by achieving greater multi-functional integration, by reducing inter-departmental rivalries and assisting the cross-fertilisation of ideas. This theoretically offers the financial benefits of greater profitability and market share as well as reductions in development costs. Furthermore, multi-functional teams may help companies to improve market targeting and planning for product families, since all staff associated with the innovation process can share their expertise. This together with the greater cross-fertilisation of ideas which is associated with multi-functional integration promotes innovation in the organisation. In this way, multi-functional team working may help the company to meet the conditions for innovation success. These results are allegedly achieved by the nature of the multi-functional team approach which brings ‘...together representatives from marketing, manufacturing, R&D, quality assurance and other departments so that they can follow a product development project from start to finish’ (Pelled and Adler, 1994, p.21).

The multi-functional team (Clark and Fujimoto, 1991; Wilemon and Millison, 1994) has been variously called the cross-functional team (Jelinek and Litterer, 1994), inter-functional team (De Meyer, 1992), multi-disciplinary project team (Takeuchi and Nonaka,



1986; Lorenz, 1987; Walsh *et al.*, 1992), multi-departmental team (Francis and Wistanley, 1987) or inter-departmental team (Adler, 1992). This research programme builds on the Pelled and Adler definition and employed the definition of the multi-functional team as including staff representing a scientific, engineering or technological disciplinary expertise, as well as business functional expertise such as sales, marketing, production, purchasing and finance.

The research aimed to compare multi-functional team approaches with other team approaches which manifest when there is either no integration of functional groups within the team or some but not full integration of all project associates within the team. When there is no integration of project associates from different functional backgrounds within a team approach, such teams are single-disciplinary, which may be also described as 'uncoordinated pipeline teams' (Durand, 1995, p.73). This team type is dominated by a single scientific, engineering or technological disciplinary expertise and excludes expertise which is relevant to the innovation process, particularly business expertise. Integrated team approaches which do not involve full integration of all project associates, are classified as multi-disciplinary teams when they include staff who represent more than one scientific, engineering or technological disciplinary expertise but exclude business expertise from the team.

Research on team approaches to the development of innovative products and processes is inseparable from an investigation of how the innovation process is co-ordinated and managed in companies. It is envisaged that this research will contribute to both an understanding of organisational team-use and the management of innovative product and process developments. Questions of which staff should be integrated, how and when during the innovation process require exploration and explanation. Research on multi-functional team approaches has been limited to minor product innovations or design improvements in large, mature firms operating in established markets, particularly in the automobile industry (Womack *et al.*, 1990; Clark and Fujimoto, 1991) and the consumer electronics industry (Durand, 1995). There is a dearth of research which describes and evaluates the way the multi-functional team concept is implemented in other industries. Furthermore, there is a need for research on the value of the multi-functional team for developing major as well as minor innovations in smaller companies as well as larger companies.



The research programme focused on the Environment Industry and all of the participating companies had projects which addressed or potentially could address opportunities in environment markets. **Chapter 3** considers the structure of the growing Environment Industry and presents the main reasons for this research focus. The OECD define the environment industry ‘...as including firms which produce pollution abatement equipment and a range of goods and services for environmental protection and management’ (OECD, 1992, p.5). It was decided to research the management of innovative products and processes developed by companies operating in this industry for several reasons.

**First**, this industry is growing and regarded as of key strategic interest by the OECD which estimated that the environment industry is worth 200 billion US dollars and will grow by 5.5% per annum to 300 billion US dollars in the year 2000 (OECD, 1992). The OECD claim that the potential growth of this sector is comparable to the aerospace and the chemical industries (OECD, 1992). This growing market has been primarily stimulated by EU regulations on environmental protection which are influenced by global environmental concerns.

**Second**, various sources express a concern with Britain's competitiveness in the growing EU and international markets for environmental technological products (See CEST, 1991; OECD, 1992; ENDS, 1992a).

**Third**, the environment industry has a dual structure, in that 50% of the industry in OECD countries is made up of small companies while 50% of the industry's output is accounted for by a small number of mature larger companies (OECD, 1992). This dual structure suggests that the industry offers opportunities for companies of different sizes. The firm size structure allows for comparison between the team approaches adopted by companies of different sizes, a key focus for this research.

**Fourth**, unlike many markets in the recessionary UK economic climate the markets for environmental products, processes and services are growing, stimulated by environmental regulations, ‘green’ pressure groups and the new commercial power of both the privatised water supply utilities and the agencies which have emerged from previously government-funded environment organisations. This is significant because innovation is likely to be more common in growing markets than stagnant or declining markets. The OECD found that the environment industry is characterised by high venture capital and high R&D requirements (OECD, 1992). However, the stimulus for radical innovation in

environmental companies may be less, since CEST suggest that much of the pollution control technology required to address environmental problems already exists (CEST, 1991). This suggests that incremental innovation will most strongly feature in this industry.

In-depth interviews and questionnaires were conducted in 25 UK based companies with 58 managers and staff members who worked on the development of innovative products and processes of relevance to the environment industry. When possible more than one member of the team was either interviewed or posted a questionnaire in order to gain greater insights into team operations within companies. This followed a sample selection of companies from several innovation award lists, directories of environmental companies, in addition to following up recommendations from personal contacts. Companies and projects were selected for this study to represent the following:

- small-sized (less than 50 employees) medium-sized (50>250 employees) and large-sized companies (greater than 250 employees);
- innovative products and processes with potential/actual environmental applications which were developed between 1988-1995;
- team and non-team approaches to the development of innovative products and processes, both in-house and inter-company projects;
- both client-funded and standardised innovative products and processes directed at open markets.

**Chapter 4** provides a full account of the research methodology adopted in this research and explains why a case study approach was adopted to achieving these objectives. A case study is described by Yin as 'An empirical inquiry that investigates a contemporary phenomena within its real life context, when the boundaries between phenomena and context are not clearly evident and in which multiple sources of data are used' (Yin, 1989, p.23). The main reasons for adopting a case study approach pertain to the exploratory focus of this research, which is essential since there is a scarcity of formal research on organisational teams (Ancona and Caldwell, 1987). Furthermore, case studies allow for an in-depth approach to explore and explain variables in complex, diverse organisations which are not easily amenable to experimental control.



**Chapters 5 and 6** address the research aim to describe the team approaches which are adopted by companies to the development of innovative products and processes. Furthermore, the research addresses the appropriateness of organisational team approaches to firms of different sizes working on projects of varying levels of innovation in **Chapter 7**. The literature points to the appropriateness of multi-functional teams to large-sized companies in the automobile and consumer electronics industries (Durand, 1995). There is a scarcity of information which clarifies the appropriateness of multi-functional teams to medium-sized and small-sized firms in other sectors.

Furthermore, the literature presents complex and sometimes contradictory evidence on the appropriateness of multi-functional teams to developing projects of varying levels of innovation. Different forms of multi-functional teams may be appropriate to developing incrementally innovative products and processes as distinct to radical innovations (Johne and Snelson 1989; Barczak and Wilemon, 1991). When projects vary in their level of innovation different issues may prevail and staff with different expertise need to be integrated (Katz and Tushman 1979; Barczak and Wilemon, 1991). Furthermore, multiple forms of organisation may be required (Johne, 1985; Twiss, 1992) with frequent re-organisation (Jelinek and Schoonhoven, 1990) to address the issues which emerge at different phases of the innovation process.

The literature suggests that team effectiveness is influenced by numerous interrelated factors which have complex impacts on team outcomes. Furthermore, the literature suggests that teams, particularly teams which integrate staff with different disciplinary expertise and project functions, offer mixed benefits and disadvantages for project development outcomes (See Table 2.8). **Chapter 8** describes team operations in terms of team member perceptions of both the positive aspects of team operations and the problems associated with teamwork. By relating accounts of team operations to perceptions of both team satisfaction and team effectiveness, it is possible to explore the relationship between team operations and the consequent evaluation by team members of the team experience and outcomes.

The final analysis is completed in **Chapter 9** which explores the significance of the team for project success outcomes. Although the literature recognises the importance of team approaches for project success outcomes, Chapter 2 shows that greater significance has been historically given to market and technology related factors than organisational, project or human resource related factors. The research helps to identify the significance of team

approaches and their effectiveness for innovation success. Although innovation success is attributable to many causes, multi-functional team approaches and their effectiveness are expected to be part of the profile of successful innovative products and processes.

It is clear from the literature review in Chapter 2 that teams are not the only integration mechanism available to co-ordinate the innovation process. The innovation process may be co-ordinated by a variety of mechanisms other than team approaches (Sect. 2.2.5). The research seeks to address the question of whether the team and in particular the multi-functional team offers the best solution to the integration problems posed by the innovation process which has historically been sequentially organised, involving staff from different departments at different phases of the process. The research contributes to an understanding of the influence of firm size differentials, inter-company project development arrangements, variations in the level of project innovation and different types of markets on innovation management. Chapters 5-10 provide in-depth descriptions of organisational team approaches and the analysis of this rich case study material contributes to our understanding of teams as a quasi-formal organisational structure, an area where the theoretical literature is limited in its understanding (See Jelinek and Schoonhoven, 1990). Furthermore, this study contributes to an understanding of innovation management in the 1990's and explores Rothwell's assertion that technological innovation requires concomitant organisational innovation, including inter-company networking and alliances as well as integrated team-working (Rothwell, 1992).



# Chapter 2 Overview Of The Theoretical Literature

## *2.1. Value Of Team Approaches*

Although teamwork in industry has existed historically in many forms, including the operational research teams of the 1940's, the project manager teams of the 1960's and the Japanese quality circles of the 1980's (Bursic, 1992), the use of teams has gained recent importance as a fundamental unit of organisational structure (Ciborra, 1993). Chapter 1 mentioned recent research which suggested that teams are the key to improving performance and competitiveness in all kinds of organisations (Ancona and Caldwell, 1987; Stewart, 1989; Kakabadse, 1991; Katzenbach and Smith, 1993). According to Tjosvold, 'Teamwork is an ultimate competitive advantage for it fuels the continuous improvement necessary to adapt and prosper in a turbulent world' (Tjosvold, 1991, p.xi).

Teams are used to fulfil many organisational functions, a fact which is reflected in the literature references to different types of teams, such as sales teams, top management teams, product design teams, quality circles, production teams, R&D teams, new product development teams and multi-functional teams. Teams are unlike committees where executive power is usually limited and centralised which may have the effect of shifting responsibility away from those actually doing the work (Johne, 1985). A team may be defined as '...a small number of people with complementary skills who are committed to a common purpose, performance, goals and approach for which they hold themselves mutually accountable' (Katzenbach and Smith, 1993, p.45). Although '...group boundaries within organisations are never quite as neat as those in the lab' (Ancona and Caldwell, 1992, p.327), the concept of team refers to a special kind of group which the author and another researcher have defined as having the following characteristics:

- it has two or more members;
- its members contribute their respective competencies, within interdependent roles towards shared goals;
- it has a team identity, which is distinct from its members' individual identities;
- it has established ways of communicating both within the group and with external teams and groups;

- its structure is explicit, task and goal oriented, organised and purposeful;
- it periodically reviews its effectiveness (Mabey and Caird, 1994, pp.7-8).

As mentioned in Chapter 1 increasing international competitiveness accelerated by the impact of new technologies, has pressurised industry to meet the challenges of higher productivity, faster product cycles, higher quality (Maccoby, 1990) and lower costs (Takeuchi and Nonaka, 1986). In a competitive climate where new products are regarded as the main source of company profits, there has been an emphasis on improving and integrating the design/manufacturing interface in the new product development process. This has led to several initiatives which have been mentioned in Chapter 1, such as Design for Manufacturing (DFM) which aims to match the efforts of design with manufacturing in innovation and the Simultaneous or Concurrent Engineering (SE or CE) initiative which optimises for the simultaneous development of process with product in innovation (Susman, 1992). The Total Quality Management (TQM) Movement is also relevant to an understanding of how management has attempted to meet the challenges of cheap, quick, high quality product development. TQM aims to avoid resource wastage with continuous quality improvement (Durand, 1995) and transform the organisation via its efficiency focus on the company-customer interface (Maccoby, 1990). The initiatives of DFM, TQM and SE all integrate appropriate management functions in new product development and teams are clearly one key way of achieving this integration. In particular, multi-functional teams which integrate ‘...representatives from marketing, manufacturing, R&D, quality assurance and other departments...’ (Pelled and Adler, 1994, p.21), potentially including planning, financial and corporate staff (Hull and Azumi, 1989), have been regarded as integrated team approaches.

Japan’s economic success has been the inspiration for the implementation of management ideas which tend to emphasise integrative management structures. Although the use of team approaches may not be the norm in Japanese firms, the emphasis is on the spirit of co-operation (Walsh *et al.*, 1992). This is associated with alleged Japanese management practices which include:

- concepts of closer inter-functional linkages, quality improvement, employee involvement through participative management (Hayes *et al.*, 1988; Tjosvold, 1991); and an emphasis on incremental improvement and learning (Funk 1993; Tjosvold, 1991);



- more integrated intra-organisational structures, such as concurrently engineered designs, multi-functional teams, product-oriented organisation structures, 'heavy-weight' project managers (Clark and Fujimoto, 1991), quality circles, flatter organisational hierarchies (Hayes *et al.*, 1988; Tjosvold, 1991);
- and more integrated inter-organisational structures, such as closer relations with suppliers and customers (Funk 1993; Tjosvold, 1991) and more alliances with both foreign companies to penetrate foreign markets and with competitors for pre-competitive research to reduce R&D costs (Tjosvold, 1991; Ciborra, 1993).

However, despite recommendations for the adoption of Japanese management practices (e.g. Hayes *et al* 1988, Clark and Fujimoto, 1991, Takeuchi and Nonaka, 1986), there have been varied reports on the uptake in European manufacturing companies. A review of the Compendex database of engineering information shows enormous interest by business organisations in the use of multi-disciplinary or multi-functional teams in manufacturing industry generally and in particular by the petroleum industry, ceramics, food and car industries (EI Compendex, 1994). The project team is arguably the most common form of organisation in engineering work (Hall, 1990). The 1993 Manufacturing Attitudes Survey found that in the UK: 'Firms...have invested significantly in product quality, new technologies and new techniques such as multi-disciplinary team working which 90% of firms claim to use' (Benchmark Research, 1993, p.3).

By contrast, in a study by De Meyer, only 36% of surveyed EU companies used team approaches to promote the integration of design with manufacturing (De Meyer, 1992). However, in an analysis of the actions of over 200 large European manufacturers to improve quality and to reduce product time-to-market and development costs, De Meyer noted that nearly half of the respondents reported a deterioration in performance and that this was associated with a low emphasis on both action programs and new product development strategies to promote the integration of design and manufacturing (De Meyer, 1992). So although there are varied reports on how widespread these practices are, the general view held is that these practices are beneficial.

Although Japanese success led to an interest in Japanese management practices, the conclusion that these practices necessarily explain Japan's success is not always valid since some studies neither measured performance indicators nor related differences between US and Japanese practices to performance outcomes (e.g. Funk, 1993). The dearth of studies

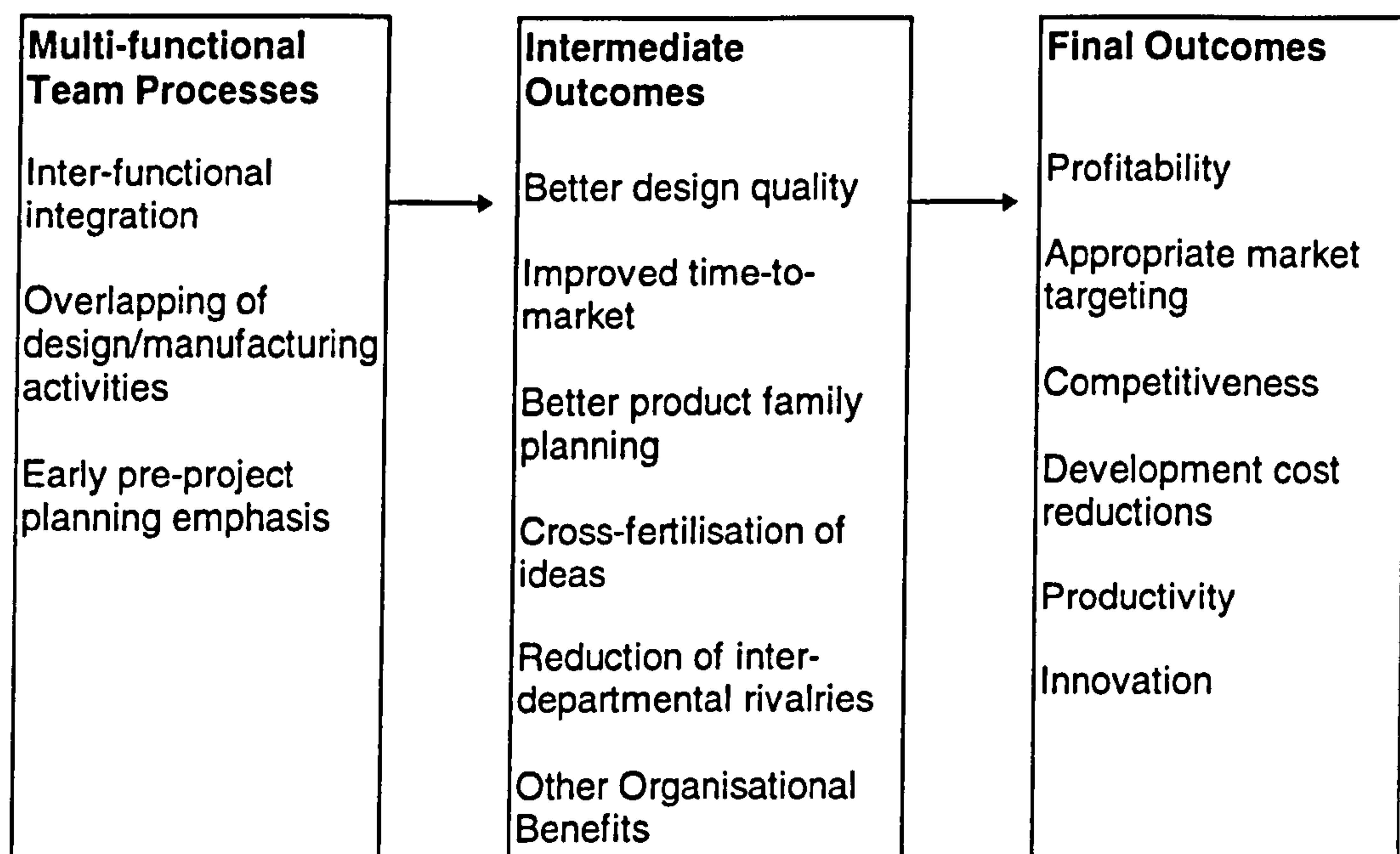
which have looked at the impact of Japanese management practices on performance slows the evaluation of these practices.

The main studies which provide evidence for the value attributed to the Simultaneous Engineering or Design for Manufacturing concept are of team approaches in the automobile industry (Womack *et al.*, 1990; Clark and Fujimoto, 1991) and consumer electronics sector (Durand, 1995). The Clark and Fujimoto study supported the idea of a multi-functional team approach as one which involves the integration of staff from all functional groups involved with the innovation process and the overlapping of work between design and manufacturing particularly at the early stages of development in order to ensure that a product is manufacturable (Clark and Fujimoto, 1991). These studies suggest that a high degree of integration has enabled Japanese car manufacturers to enjoy shorter lead-times than those achieved in US and Western Europe by addressing the problem of managing the large number of functional departments involved (Clark and Fujimoto, 1991).

The attractive benefits of a better, more manufacturable product which is cheaper to develop, quicker to market and more competitive arise not only from an emphasis on Simultaneous Engineering but also from an emphasis on the pre-project planning phase which arguably is the time of greatest managerial influence on the direction of the project (Hayes *et al.*, 1988). The project's direction is difficult to change later on in the process and without the early establishment of strategic direction, the project becomes the vehicle through which the organisation figures out what its strategy is (Hayes *et al.*, 1988). Figure 2.1 illustrates the alleged benefits and outcomes which allegedly lead from the implementation of multi-functional team processes which are discussed in greater detail as follows.



Figure 2.1. The Benefits/Outcomes Associated With Multi-functional Team Processes



Several studies have supported the benefits of multi-functional team approaches for improving product time-to-market which is associated with the advantages of greater product profitability, a more competitive customer-relevant product and development cost reductions (Hayes *et al.*, 1988; De Meyer 1992; Benchmark Research, 1993; Hitt *et al.*, 1993). For example, a team approach allowed for the development of the IBM PC in less than one year by a team of 12 staff (Yeaple, 1992). In one study, car firms in Japan were compared with the US in the 1980's with findings that US car firms took nearly twice as many engineering hours (3 million compared with 1.7 million hours), had bigger project teams (90.3 compared with 48.5 staff) and took approximately a third longer than the Japanese development time and concluded that the Japanese were much faster, leaner, more cost-effective and ultimately more competitive (Clark and Fujimoto, 1991).

A fast development time-to-market is valuable for markets where a delayed introduction can have a negative effect on the overall profitability of the innovation project (De Meyer, 1992). There is some evidence that it is more profitable to be faster to market than to remain within budget according to a report by the McKinsey consultants, who reported that high-tech products developed within budget will earn 33% less over 5 years by coming to market 6 months late, by comparison with products brought to market on time but 50% over budget with the result that profits were only reduced by 4% (See Hitt *et al.*, 1993). There was further support for the value of the multi-functional team for profitability with a

study of 20 labs which found that higher sales were associated with more teamwork among R&D specialists, between R&D and other functions and a greater linking of upstream with downstream activities as well as a greater group responsibility for project goals; these variables explained at least 80% of the variance found in sales from new products (Hull, 1990).

Furthermore, early pre-project planning and inter-functional integration are important for development cost reductions because several researchers have argued that 80% of manufacturing costs are committed in the first 20% of the design phase which represents a significant percentage of overall costs (See Hitt *et al.*, 1993). This implies that when downstream activities, such as manufacturing, testing, marketing and servicing are not considered at the design phase, this may result in high product costs and low product quality (Hitt *et al.*, 1993). Unlike Japanese firms which emphasise the early phases, there was a tendency for Western firms to pursue improvements in cost, quality and time at the middle phases of development, of design prototype preparation and pilot production (Hayes *et al.*, 1988).

A shorter development cycle arguably brings a competitive advantage since the product reflects a more up-to-date assessment of customer needs, a better design quality by removing the 'moving target' or 'specification creep' problem which is associated with long development cycles as well as lower costs, providing management does not simply add people in order to make good time-to-market (Hayes *et al.*, 1988). Furthermore, multi-functional integration assists product family planning (Rothwell, 1992) since all staff involved with innovation can share their expertise. The benefits of this are associated with the overlapping of design and production activity which allows for a more manufacturable and therefore better product design, even if the downstream group begins work early with only fragmentary information (Hayes *et al.*, 1988).

The value of multi-functional teams for improving design quality has been supported in UK manufacturing firms (Benchmark Research, 1993). Furthermore, a case study which contrasted simultaneous engineering approaches, where firms prepared for production while the design process was still in progress, with more traditional management approaches showed that simultaneous engineering led to a better, simpler product which was easier to manufacture (Riedel and Pawar, 1991). This study supported attributions of improved design quality by embracing simultaneous engineering principles, although not necessarily the cost-effectiveness benefit (*ibid.*, 1991). However, the researchers argued



that the value of simultaneous engineering depended on the teams themselves and the business strategy adopted (*ibid.*, 1991).

Previous research supported the value of teams in general for enhancing productivity, for example Trist's research on coal mining work groups found that when a team approach involving voluntary selection, team member management and team rewards for shift *cycle* completion rather than rewards for shift *task* completion, there were significant increases in productivity (Trist *et al.*, 1977). This was attributed to reduced competition between shift workers, an increase in workers' anticipation of the implications of their work for later shift workers and a perception of equal contribution to the whole production goal (*ibid.*, 1977). Greater integration of staff expertise is also associated with greater cross-fertilisation of ideas (Von Hippel, 1988; Drucker, 1991; Roy, 1992; Caird, 1994a) which supports organisational innovation (Twiss, 1992).

The implied benefits of teamwork for team processes is supported by the 1993 Manufacturing Attitudes Survey which found that of the 90% UK firms surveyed which used multi-disciplinary teams, the majority of firms recorded increased motivation and inter-departmental communication (Benchmark Research, 1993). Team management practices may also help to address well-commented-upon tensions and reduce inter-departmental rivalries between design and manufacturing staff (Shiner, 1992) which can lead to costly product design amendments pre- or post-market launch and longer development cycles (See Walsh *et al.*, 1992). Research with five high-tech firms which aimed to overcome ineffective relations between integrated marketing and R&D functions suggested that integration not separation was the solution and this was promoted through the creation of an open environment using joint project teams, the location of marketing staff in the R&D area, shorter lines of communication between groups as well as formal linkages through shared budget control (Shiner, 1992).

Integrated teamwork, through the overlapping of product development steps, 'enhances shared responsibility and co-operation, stimulates involvement and commitment, sharpens a problem-solving focus, encourages initiative taking, develops diversified skills and heightens sensitivity toward market conditions' (Takeuchi and Nonaka, 1986, p.141). Research with 492 computer team executives suggested other organisational advantages associated with the team experience:

- greater user participation;

- improvement of interdepartmental communications;
- improved information flow;
- improved access to technical talent;
- improved morale;
- improved efficiency through shared resources;
- the encouragement of organisational unity (Ford and McLoughlin, 1992).

On the other hand, the disadvantages of integrated teamwork were that it intensified the management process resulting with tensions and communication difficulties (Takeuchi and Nonaka, 1986). Further disadvantages noted include:

- accountability problems with more than one boss and authority versus accountability issues in matrix structures;
- time wastage;
- slow decision making;
- problems with the efficient utilisation of people;
- problems with re-integration back into the organisation following the completion of the project (Ford and McLoughlin, 1992).

It is clear that teams have advantages and disadvantages. Ford and McLoughlin's research suggested that the advantages of teams may be most evident in more effective teams because their research with 492 computer team executives showed that the advantages of teams were appreciated most strongly by high-performing teams not the under-performing teams, although the statistical significance of the differences was unclear (*ibid.*, 1992).

In summary, there is some evidence to prove the value of multi-functional team approaches for enhancing the technical and commercial performance of innovative product and process developments in organisations. However, a more extensive literature review is necessary to consider the advantages and disadvantages of teams in greater detail and the influence of different conditions in the organisation, market, project and team on team effectiveness and project outcomes.



**Key Research Question:** This explores the value of multi-functional team approaches for the success outcomes of innovative product and process developments of varying levels of innovation in environmental organisations of different sizes operating in different market sectors, by observing (1) team satisfaction and effectiveness (2) technical performance (3) commercial performance. This chapter assesses the available literature around the following key areas, each of which helps to shape the thesis hypotheses. Section 2.2. explores the nature of organisational teams in the context of the management approaches and organisational structures adopted for the management of innovation. Section 2.3. and 2.4 explores the appropriateness of multi-functional teams to developing products and processes of varying levels of innovation in organisations of different sizes. Drawing on group psychology and the team literature, Section 2.5. discusses the antecedents and nature of team effectiveness, arguing that the success outcomes of multi-functional and other team approaches are influenced by team processes and moderated by team effectiveness. Finally, Section 2.6. explores the conditions for innovation success and the place for multi-functional teams as one of the many factors influencing success.

## ***2.2. Co-ordination Of Innovation***

A movement described as the Management Of Technology movement has arisen due to challenges of new technologies and the requirement for new management theories, since it is perceived that classical management theories are inadequate to handle new complexities associated with rapid technological change and intensified competition (Jelinek and Schoonhoven, 1990; Souder and Sherman, 1994). One technological paradox is that despite enormous technological resources, many traditional firms seem unable to innovate effectively (Jelinek and Litterer, 1994). The search for appropriate organisational practices has been influenced by the growing perception that organisation itself is a competitive advantage (Tjosvold, 1991) and that poor organisation designs tend to be accident-prone (Hayes *et al.*, 1988). The ‘...task of the 20th century is organisational inventiveness’ in companies (Burns and Stalker, 1966, p.96).

This section outlines the relationships between models of the innovation process and approaches to the organisation and management of innovation with a view to exploring the nature of new management practices, such as the use of teams. However, Souder and Sherman admit that there are no universal prescriptions available since the challenge of management

‘...changes with technologies, people, cultures, processes, organisations, groups, customers, products, knowledge, past experience - the list of contingencies is nearly endless. ...Yet...the notion persists that there must be some baseline best practices, principles and theories that can be used to guide the effective management of new technology developments’ (Souder and Sherman, 1994, pp.3-4).

### **2.2.1. Models Of Innovation**

Recommendations for the management of innovation have tended to follow theoretical understanding of the innovation process. Innovation involves the commercialisation of technological change (Rothwell, 1992). Innovation may be an activity or an outcome (Walsh *et al.*, 1992) and as an activity the typical innovative product development process or new technological development process involves idea generation, concept development, market definition, R&D, manufacturing, launch and follow-up service, although variations are possible and the process can be compressed or sped up by accelerating some steps, combining adjacent steps or omitting steps (Souder and Sherman, 1994).

Following research by the author which involved interviews with small business innovators, some insights into the innovation process were drawn. Invention and innovation may be distinct activities and outcomes although they are often part of the same process: invention may be described as an original, technical and patentable process with no necessary commercial application; whereas innovation usually involves the application of something new or in a new way to solve a problem usually for commercial gain (Caird, 1994a).

While it is generally accepted that technology is changing it is less recognised that the innovation process is changing and with that the understanding of how innovation is managed and should be managed (Rothwell, 1992). A mixture of description and prescription, not always clearly distinguished is present in Rothwell’s review of the changing models of the innovation process, as summarised below:

1. The 1950’s -60’s period of post-war recovery was dominated by the growth of new technology-based sectors. This led to a ‘technology push’ model of innovation, which regarded scientific discoveries as the source of the innovation process. This model lost credibility with the recognition of the importance of market factors.



2. In the early 1970's another linear model described alternatively as the 'need pull' or 'market pull' model regarded the market as the source of innovation. However, both 'technology push' and 'market pull' linear models became regarded as oversimplified and instead both marketing and technological factors were acknowledged to have greater importance at different phases of the innovation development process; as the technology matures the industrial markets become more important, by contrast with new technology where scientific discoveries are more initially important than market forces (See Abernathy and Utterback, 1988).
3. Between the late 1970's-1980's the 'coupling model' or 'interactive model' of the innovation process dominated perceptions where innovation was regarded as a sequential but not necessarily continuous process (Freeman, 1986).
4. Between the late 1980's-1990's the 'integrated model' of innovation prevailed which reflected a marked shift in the perception of innovation as a sequential process to being largely a parallel process. This reflected the influence of Japanese practices, such as team-working.
5. In the 1990's, Rothwell proposed what he called the 'Fifth Generation' model of innovation or the SIN model 'Systems Integration And Networking Model'. This model recognised the impact of major new technologies which led to the electronification of the innovation process. This is responsible for increasing technological competition and speeding up product cycles and led to greater inter-company networking and other arrangements, such as joint-ventures, co-production agreements, cross-distribution arrangements and technology licensing (Teece, 1986; Rothwell, 1992). Other changes in management practices associated with innovation include time-based strategies for product families, an emphasis on DFM and product quality and a greater awareness of environmental issues (Rothwell, 1992).

The elements of this 'Fifth Generation' model reflect claims that there is a paradigmatic shift taking place in the management of innovation due to the pressures of international competition which are summarised by the author in Table 2.1 (Table 2.1 draws from the following: Hayes *et al.*, 1988; Susman, 1992; Wilemon and Millison, 1994; Jelinek and Litterer, 1994). The main theme of these emergent organisational forms is inter-dependency (Maccoby, 1990). Furthermore, the 'Fifth Generation' model is as much a prescription as a description of current innovation development processes; Rothwell argues

that this innovation model can help firms to address problems with external relationships (Rothwell, 1994).

Table 2.1. Contrasting The Traditional With The Emerging Paradigm In The Management Of Innovation

Developed by Author

Characteristics	Traditional paradigm	Emerging paradigm
Project phases	Linear/sequential	Overlapping/multi-functional team effort
Departmental relations	Functional separateness	Cross functional integration
Project Focus	Company driven	Customer solution driven
Innovation Strategy	1. Less competitive orientation	1. Competition on time-to-market, quality, and low cost
	2. Intermittent projects	2. Continuous innovation and focus on developing product families
	3 Single firm development	3. Networking and inter-company integration, including suppliers, customers and competitors
Company outlook	Domestic	Global
Changing company attitudes	1. Single loop learning where orthodox disciplinary methods are enforced	1. Double loop learning, where assumptions are regularly questioned
	2. Quality viewed as expensive	2. Quality reduces cost
	3. Efficiency/cost focus	3. Focus on effectiveness and efficiency with importance of time-to-market
	4. Short-term sales and profits used to measure success	4. Long-term customer satisfaction and future business potential used to measure success

## 2.2.2. Management Of Innovation

A summary of the history of changes in the innovation process shows that approaches to the organisation and management of innovation are inspired by models of innovation. Understanding of the innovation process has evolved to recognise that the key management challenge is how to achieve the requisite inter-functional integration of those involved with developing innovative products and processes. This is evident in the typologies of management considered below, although they present a more simplistic view of the best practices implied by the different ways that the innovation process may be organised, reviewed in Section 2.2.3. (See Table 2.2).

### 2.2.2.1. Sequential Approach

The sequential approach to product innovation is linear, involving the sequential development of new products, from the ideas stage through to commercialisation (Francis



and Winstanley, 1987). The author suggests that the sequential approach is a catch-all description for the management approaches implied in the 'technology push', 'market pull' and 'coupling models' (See Rothwell, 1992). The approach is analogous to the 'relay race' approach (Lorenz, 1987; Takeuchi and Nonaka, 1986) and corresponds to a traditional functional-based management approach (Hayes *et al.*, 1988).

It is associated with bureaucratic forms of organisation where lower-level jobs are simplified and co-ordinated by staff at higher hierarchical levels (Weber, 1947). It stems from the view that scientific methods could be used to design jobs absolutely to meet organisation purposes (Taylor, 1947). There are several limitations to this bureaucratic approach.

**First**, a study of mainly large firms showed that difficult departmental interfaces are highly enduring, particularly for departments with greater levels of interdependency and relatively impermeable boundaries (Elmes and Wilemon, 1991).

**Second**, inter-departmental conflicts provoke political processes in organisations, since: 'Functional areas are rarely 'created equal' and thus power differentials may exist' (Hitt *et al.*, 1993, p.167).

A **third** problem with the standard departmentalisation of R&D, engineering, manufacturing and marketing is that it produces different time horizons, different patterns of authority and interaction and different views of the wider environment and associated uncertainties (Jelinek and Schoonhoven, 1990).

**Fourth**, within the sequential approach there is little communication between the different departments involved with each stage of the process (Francis and Winstanley, 1987). Functional specialisation and poor inter-functional communication hinder inter-functional integration (Hitt, *et al.*, 1993) which is important for achieving innovative development goals and benefits which have been discussed in Section 2.1. It has been argued that co-operation problems may impact more on psycho-social outcomes <sup>1</sup> than task outcomes (Pinto *et al.*, 1993), although presumably there is a relationship between both outcomes.

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<sup>1</sup> Psycho-social outcomes here refer to satisfaction with both project outcomes and the experience with other team members.

The sequential approach may be advantageous for the acquisition of disciplinary knowledge and the satisfaction of professional wishes (Twiss, 1992). However, the evidence strongly suggests that the consequences are mainly disadvantageous.

First, the cross-fertilisation of ideas is not facilitated and may slow project completion because goals are departmental rather than project based (Twiss, 1992).

Second, there is a low transfer of learning between new projects and the tendency to develop me-too products due to the fragmented approach to development and poor inter-functional integration (*ibid.*, 1992).

Third, this approach even when working well tends not to lead to rapid production (Francis and Winstanley, 1987). It is a fragmented linear approach, where later development cannot begin until prior steps are completed which leads to time pressure during the final steps (Wilemon and Millison, 1994). Furthermore, there is a high probability for total product re-design due to the failure to look ahead which again slows production (*ibid.*, 1994).

#### **2.2.2.2. Iterative Approach**

With this approach the departments involved in product innovation pass the work backwards and forward in order to develop a manufacturable design (Francis and Winstanley, 1987). Communication between design and manufacturing is likely to be fraught because it is associated with delays and poor satisfaction with design work (*ibid.*, 1987). The Sequential and Iterative approaches are related and not mutually exclusive, since the latter results from poor integration of design with product manufacturing requirements. An analogy is a volley ball game (Lorenz, 1987), although this analogy is limited since the Iterative approach arises from problems with the sequential approach and the game of volley ball is not suggestive of a dysfunctional approach.

‘The traditional New Product Development (NPD) paradigm gives the appearance that some functions or organisational groups could successfully perform the tasks of each process step without integration with other functions....Not only does inter-functional integration need to occur during each step of new product development but multi-functional approaches are needed to bridge gaps between steps’ (Wilemon and Millison, 1994, p.255).



### ***2.2.2.3. Multi-Departmental Approach***

In general, organisations have a natural tendency to become more bureaucratic (Hayes *et al.*, 1988) or mechanistic where functions, methods, responsibilities and powers are clearly defined through specialisms and managed through a complex hierarchy where information flows up and decisions and orders flow down (Burns and Stalker, 1966). Kanter claims that organisations with integrative structures and cultures ‘reduce rancorous conflict and isolation between organisational units; create mechanisms for exchange of information and new ideas across organisational boundaries; ensure that multiple perspectives will be taken into account in decision making; and provide coherence and direction into the whole organisation’ (Kanter, 1983, p.28).

With the multi-departmental approach all the departments concerned with the product innovation process work together throughout the product innovation process. The need for strong integration was particularly stressed by researchers who see the product innovation process ‘as a sequence of interrelated multi-functional efforts’ (Thamhain, 1990, p.6) and essential for success in technology-based organisations (Elmes and Wilemon, 1991). The multi-departmental approach is regarded as a highly communicative process between the departments involved (Francis and Winstanley, 1987).

The importance of inter-functional integration is supported by evidence that innovations come from diverse sources (Von Hippel, 1988; Drucker, 1991; Roy, 1992; Caird, 1994a). Von Hippel's work on sources of innovative ideas shows that many of these come from the user, the supplier or manufacturer (Von Hippel, 1988) and there are both internal and external organisational sources of innovation (Drucker, 1991). Furthermore, many innovations originate in the integration of different disciplines and business functions which brings together an awareness of both technological and market opportunities. Evidence suggests that the sources of innovation include the following:

- adaptation, of an existing concept, solution or technology to a new application;
- transfer of expertise from one application to another;
- analogy, that is an innovative solution is suggested by a similar situation;
- combination of existing ideas/technologies to provide something new (Roy, 1992).

Multi-departmental approaches are analogous to the rugby team approach (Takeuchi and Nonaka, 1986; Lorenz, 1987) and have also been called tiger teams (Hayes *et al.*, 1988). Multi-departmental teams may be set up without the requirement for total integration of team members throughout the development process. In a fully integrated team approach, team members could work together from beginning to end whereas in a less integrated team approach, the team members may integrate their different functions at the border of adjacent phases; the latter limits the integration in the 'sashimi system' (Takeuchi and Nonaka, 1986). Multi-functional team integration may be achieved by either lightweight or heavyweight project manager systems, where the project manager co-ordinates representatives from different departments (Hayes *et al.*, 1988). The heavyweight project manager system involves a senior rather than the junior project manager employed by the lightweight system and may be preferable since it gives the project manager more authority and a greater chance of project success (*ibid.*, 1988).

Recommendations for the implementation of team approaches have been drawn from observations of Japanese and US companies and include giving value to greater autonomy, equality as well as more flexible, less hierarchical structures in teams (Takeuchi and Nonaka, 1986). Further recommendation include that:

1. Teams should be self-organising and top management should give teams the autonomy to work together to set challenging goals. These teams can acquire stature in the organisation through their visibility, legitimate power and sense of mission and should transcend themselves through the integration and cross-fertilisation of ideas from members with diverse functional backgrounds.
2. Product development phases should be overlapped to promote integration and speed in the process. This could require the reduction and aggregation of previously recognised steps in the development process. Central to this recommendation is the notion that the division of labour is irrelevant since responsibility is shared by the team who are forced to learn beyond their job and functional expertise.
3. Projects should be subtly controlled by selecting the 'right people in the first place', creating an open environment, promoting communication between areas of functional expertise and with customers and suppliers, rewarding the team rather than individual efforts, tolerating mistakes, encouraging trial and error and recognising the changing requirements of each phase of the innovation process. Furthermore, strategic decisions



should be delayed (although not operational decisions) in order to allow for a flexible response to market feedback (*ibid.*, 1986).

Multi-departmental approaches to the management of innovation may reflect the 'coupling model' of innovation in the less integrated sashimi system or the 'integrated model' of innovation in its more integrated rugby or tiger team form. Furthermore, the 'Fifth Generation model' with its emphasis on inter-company networking and integration is partially represented by multi-departmental approaches. Multi-departmental approaches are inspired by Japanese management practices which favour integration with customers, suppliers and even competitors (Tjosvold, 1991). However, inter-company networking has not been particularly focused on in discussions of multi-departmental approaches and it may be argued that the 'Fifth Generation' model of innovation represents a development on multi-departmental management practices.

### **2.2.3. The Team In Organisational Theory**

Although multi-functional team approaches are an important part of the new paradigm for the management of innovation, there are criticisms of organisational theory for focusing on only two alternative organisational structures, formal and informal, thereby ignoring teams which are quasi-formal structures, (Jelinek and Schoonhoven, 1990). Furthermore, while the use of teams is recognised, typologies describing the organisation of innovation fail to make their place clear in typical organisational structures used for the management of innovation (See Twiss, 1992).

It is likely that teams will be influenced by the underlying organisational structure which can vary significantly in the firm. It is alleged that organisation structure determines the nature and difficulties of organisation (Hayes *et al.*, 1988). In more bureaucratic organisations, when team approaches are adopted they are likely to encounter problems related to their lack of a formal role in organisation and the difficulty in managing teams through several layers of hierarchy (Maccoby, 1990). In view of the influence of organisational structure on teams, a consideration of organisational structures (adapted from Twiss, 1992) which underlie the management of innovation suggest that while multi-functional teams may manifest in differing organisation types, there will be significant differences between these teams.

### 2.2.3.1. Organisation Of Innovation

Twiss outlines six main ways that innovation developments may be organised including organisation by: scientific discipline, product line, matrix management, venture management, project manager and joint venture management (Twiss, 1992). These organisational structures are discussed below in terms of their implications for team use with greatest attention given to the first four structures since the project management and joint venture forms of organisation are usually imposed on one of the other four forms.

First, the author suggests that the 'technology push model' of innovation supports a discipline-based organisation structure for innovation management, which can also be called functionalisation (Hayes *et al.*, 1988). All the limitations of sequential approaches are likely to apply, although these may be ameliorated if co-ordination mechanisms are installed. Any team approach adopted within this structure would be single-disciplinary or 'uncoordinated pipeline teams' (Durand, 1995, p.73) and influenced by the following related advantages and disadvantages.

#### **Scientific Discipline Organisation (adapted from Twiss, 1992).**

##### Advantages:

- may be the most appropriate to the development of technological capital or technology transfer
- supports the acquisition of knowledge and development of technological capability
- satisfies team members who enjoy developing their professionalism
- appropriate to mature, traditional industries, where technical changes occur at a slow pace or in an incremental manner (Holt, 1987).

##### Disadvantages:

- may lead to difficulties in maintaining commercial interests and the importance of overall project goals rather than disciplinary or departmental goals
- may be poor cross-fertilisation of ideas and innovation is more likely to emerge from combinations of technologies or different disciplinary ideas than from within disciplines, since disciplinary boundaries support the orthodoxy of established methodologies and boundaries
- may be co-ordination problems

Second, the author suggests that 'market pull' model of innovation supports an organisation by product line which is also called divisionalisation (Hayes *et al.*, 1988) and applies particularly to the larger firm. Organisation by product line is a structure which links R&D with marketing on a product line within a market-oriented divisional structure (Twiss, 1992). A multi-functional team though possible within this organisational structure is unlikely to manifest as the fully integrated tiger or rugby team approach as a result of departmental boundaries. Teams may be 'sequential co-ordinated teams' which have intermediate levels of concurrency in the organisation of staff integration for



innovation (Durand, 1995, p.73). However, teams are not the only co-ordination mechanism which may be adopted within this form of organisation and co-ordination mechanisms may be installed to reflect different models of the innovation process, such as the 'coupling' or integrated' models of innovation.

**Product Line Organisation (adapted from Twiss, 1992).**

Advantages:

- the marketing orientation of the R&D staff is greater and their work is likely to be closer to the customers' requirements
- if a project manager is involved, their seniority and authority may be necessary to support project success

Disadvantages:

- R&D work is managed by divisional heads with responsibilities for products which can disperse the authority of an R&D director and allow for little co-ordination of R&D work between product divisions
- if a project manager is used and has either poor status, little power within the organisation, or poor relationships with the departmental heads, there is a little chance of project success, since team members' opportunities lie within the department and not the project team which usually has a life limited to the project.

Third, the author suggests that the matrix structure organisation, which is organised along managerial and professional lines, is supported by the 'coupling' or 'integrated' models of innovation. Disciplinary heads guard the professional standards and project managers organise for the success of product developments. Multi-functional teams led by project managers characterise team approaches adopted within this structure. For example, in a study which compared the US company General Motors unfavourably with Honda, it was found that Honda used a matrix structure from which staff were allocated to teams for the life of the project (Womack *et al.*, 1990).

**Matrix Structure (adapted from Twiss, 1992).**

Advantages:

- allows for employees to pursue professional development and career interests within long-term divisional structures and contribute to projects
- the project manager has formal status
- permits the gradual transition of a project from R&D to production without the discontinuity involved in a formal transfer between departments
- multi-functional teams help with communication, particularly if problems arise with early production models or production plants, and allows for a greater orientation towards the market and the customer

Disadvantages:

- responsibility and authority may not be equated and usually are not
- employees report to more than one manager which can create role conflict or work overload
- there can also be internal power struggles over shared resources between discipline heads and project managers which can have adverse consequences for project management.

The author suggests that the **fourth** structure, venture management organisation is supported by the 'integrated model' of innovation. The venture management organisation reflects the value attributed to the small entrepreneurial enterprise, where few formal structures are required to manage operations. Multi-functional teams within this organisation structure are likely to be emergent and structured informally. However, the venture management structure is not exclusive to the small firm and in the large organisation it is often split off from the rest of the organisation (Johne, 1985). A review of 2,300 important innovations introduced in the UK 1945-1980 showed that larger firms have increasingly innovated via smaller units (Townsend *et al.*, 1981).

**Venture Management (adapted from Twiss, 1992).**

Advantages:

- little bureaucracy, entrepreneurial management, rapid decision-making, ease in communication, integration, risk-taking and innovation (Rothwell, 1994)
- flexibility and adaptability
- easier to maintain team spirit
- useful for the rapid exploitation of specific innovations
- helps to contain the disruptive impact of radical innovation on the on-going activities of a firm while supporting diversification activities (Johne, 1985).

Disadvantages:

- success is very dependant on the entrepreneurial skills of the manager
- career opportunities may be limited
- when the venture is split off from the rest of the company, it can become insular, institutionalised over time and lose the innovative edge (Johne, 1985).
- may be costly and vulnerable if the company strategic situation changes (*ibid.*, 1985).
- may not be good idea to split innovation away from the responsibility of the rest of the company (*ibid.*, 1985).

### ***2.2.3.2. New Organisational Approaches To The Management of Innovation***

Management innovation may offer a greater economic advantage than technological innovation and organisational learning is the principle process by which management innovation occurs (Stata, 1989). Peter Stata, the chairman of Analog, has argued that Japan's rise to industrial power was based more on management innovation than technological innovation in the traditional sense (*ibid.*, 1989). In relation to the economic promise of management innovation, new types of organisation have been postulated to address the pressures of intensified global competition and the competitive pressures recognised by the 'Fifth Generation' model of innovation (Rothwell, 1992).



'The new forms of organisation that are developing to cope with the complexity of the global high-technology marketplace are themselves innovations, demanding ongoing learning and re-designing by organisational members' (Mohram and Glinow, 1990, p.268).

As a stimulus for management innovation, technological innovation may create the requirement for company innovation at several organisational levels such as:

- organisational innovation e.g. a new venture division, matrix structure;
- management innovation e.g. a new inter-functional liaison system;
- production innovation, e.g. a quality control circle;
- commercial/ marketing innovations e.g. new financial arrangements (Rothwell, 1992).

This classification of company innovation may be arbitrary since the probability is that innovation on any company level will affect the company as a whole. For example, the trend towards the organisation of design and manufacturing through extensive supply chains rather than primarily in-house (Potter *et al.*, 1994) impacts on the whole organisation.

Section 2.2.1. has already discussed the emerging paradigm in innovation management. This is supported by Maccoby's claim that there is a replacement of bureaucratic forms of organisation with the techno-service organisation which is characterised by the following:

- more organic management;
- flatter organisations, teams, flexible work roles;
- extensive networks (Maccoby, 1990).

These characteristics also describe the real-time organisation (Jelinek and Litterer, 1994). In addition the real-time organisation values many of the Japanese practices mentioned in Section 2.1. The real-time organisation:

- uses technology effectively;
- has a charismatic and task-based style of leadership which wins employee commitment;
- values employee empowerment, shared management and a shared strategic vision;

- has a culture which supports continued process improvement (*ibid.*, 1994).

However, it is not clear how new such organisational forms are since they embody many characteristics of the organic system of management which is characterised by less absolute definition with continuous re-definition in job responsibilities, job descriptions, organisation and strategy, so that the organisation is characteristically flexible and adaptable to unstable conditions (Burns and Stalker, 1966). With the organic management system, communication is lateral and control and authority are maintained through a network structure rather than a hierarchy (*ibid.*, 1966). However, new ideas on organising innovation represent a significant development on the work of Burns and Stalker in the 1960's since they are more rooted in contemporary organisational practices and the concerns of management in the 1990's.

The influential findings of Burns and Stalker's research were derived from a study of 20 companies. The 'ideal' organic management system is arguably more appropriate to the management of innovation and rapid environmental change than the 'ideal' opposite pole which is the mechanistic management system (Burns and Stalker, 1966). The reincarnation of the organic system of management in the form of the 'real-time organisation', 'techno-service organisation' or 'venture management' structure reflects a swing from more mechanistic forms of management to organic forms of management (Burns and Stalker, 1966); the former favours differentiation in management which supports control, whereas the latter favours greater integration in management which supports autonomy (Lawrence and Lorsch, 1965; Maccoby, 1990) and may be more appropriate to managing in uncertain markets.

However, new organisational approaches to innovation need to be more than a mere reincarnation of the principles of the organic management system. The *ad hoc* organic organisations often recommended for the management of innovation described as '*structure du jour*' have been criticised as 'too chancy' or even worse than useless (Jelinek and Schoonhoven, 1990, p. 263). Some combination of organic and mechanistic management principles may be needed to address the organisational paradox evident in management's simultaneous need for both autonomy and control. There is some evidence that successful Japanese companies (e.g. Mitsubishi and Yokagawa Electric) unlike comparative US firms implemented strategies using a unique combination of organic management mechanisms such as open offices, product-oriented organisation and



decentralised decision-making, as well as mechanistic mechanisms, such as high levels of formalisation, detailed schedules and complex office structures (Funk, 1993).

High-tech organisations need to be learning systems (Jelinek and Schoonhoven, 1990) and not bound by absolute management prescriptions for organic management approaches or any other. This is manifest in findings based on 100 interviews in high-tech semiconductor and computer firms which identifies four key aspects of organisation structure in high-tech innovative firms:

- clear well articulated structures, defined reporting relations and clear job responsibilities which helps firms to manage change;
- frequent formal reorganisation which may be appropriate throughout the innovation process, since this creates dynamic tension between stability and change;
- use of quasi-formal structures, such as teams and committees which are formal with respect to their problem solving status but less formal in terms of authority relationships;
- informal structures of organisation which reflect the requirements of high-tech companies for both lateral and vertical communication. These structures include loose coupling of different disciplines and business functions with little attention to hierarchical status and symbols (Jelinek and Schoonhoven, 1990).

They concluded:

‘Clear organisational structures, frequent reorganisations and an extensive use of quasi-structures are significant contributors to the long-term innovative abilities of the high-tech companies we have studied; a dynamic tension between stability and change’ (*ibid.*, 1990, p.294).

In general, hybrid or multi-structured organisations have emerged to address the changing challenges of the innovation process (Johne, 1985; Twiss, 1992). Although these structures were recognised in the 1980’s by John, his work was too early to note the increasing importance of the extra-organisational context, as represented by the ‘Fifth Generation’ model of innovation which emphasises networking and inter-company alliances (Rothwell, 1992). The new structures reflect a swing to organic principles of integration in management and the requirement for organisational innovation and learning

to meet the challenges of intensified competition in the 1990's. Hybrid structures and reorganisations may be required for the management of specific projects at different stages of development. Furthermore, hybrid structures may be important either when the innovation management function is split off from the rest of the organisation or in joint-venture projects where companies combine their technological capabilities to test new markets and spread R&D costs (Twiss, 1992). In this way, hybrid structures represent a form of both organisational and inter-organisational innovation and may involve the integration of different departmental and strategic interests, different organisation structures, different time horizons, different departmental and organisational cultures and different sources of authority during the development of innovative products and processes.

#### 2.2.4. Implications Of Innovation Models For Team Use

Table 2.2. simplifies the proposed linkages which have been discussed above between the models of the innovation process and appropriate management approaches and organisational structures.

Table 2.2. Relationships Between Models Of Innovation, Organisation Structures And Management Approaches

(Developed by Author)

Models of Innovation	Related Management Approaches	Appropriate organisational structure(s)
Technology push	Sequential and iterative	-Discipline based
Market pull	Sequential and iterative	-Product line
Coupling	Sequential, iterative or multi-departmental sashimi approach	<u>The use of co-ordination mechanisms with the following:</u> -Discipline based -Product line
Integrated	Multi-departmental (sashimi approach and rugby or tiger team approach)	-Product line with the use of co-ordination mechanisms, -Matrix -Venture management
Fifth Generation	Multi-departmental (sashimi approach and rugby team approach) as well as new paradigm inter-company approaches	New organisation forms such as techno-service or real-time organisation  Multiple or hybrid structures e.g. Joint ventures, organisations embracing several structures for different projects or project phases

Some of the complexity of the concepts and terminology employed in the area of innovation management is elucidated by the exploration of linkages between the models of the innovation process, management approaches and the organisation structures underlying



innovation above. It is clear from this review that when quasi-structures such as team approaches are adopted, there are several possible manifestations for the team which reflect the combinations of organisational structures and management approaches which may be adopted for innovation management. The implications are that teams are largely differentiated by the nature and extent of the team member integration permitted by the underlying organisational structure and the management approach adopted.

This Section implies that many types of teams may be adopted which warrant consideration and these will be influenced by the associated advantages and limitations of the approaches adopted for the organisation and management of innovation. Not all team types are recommended and in particular the more formally structured, less functionally integrated teams tend not to be recommended (See Takeuchi and Nonaka, 1986). However, Twiss claims all organisational solutions to the management of innovative process will have shortcomings (Twiss, 1992). Even the team approach recommended by Takeuchi and Nonaka requires 'extraordinary effort on the part of all project members throughout the span of the development process' (Takeuchi and Nonaka, 1986, p.145; See Section 2.2.2.3. for description). According to Walsh *et al.*, there is no ideal organisation '...some studies ...tend to be rather simplistic, advocating multi-disciplinary project teams for most situations. The essential factor seems to be that there are organisational structures that somehow enable all relevant individuals and departments to participate in product development and ensure that their contributions are properly co-ordinated'(Walsh *et al.*, 1992, p.8).

#### **2.2.5. Changing Management Throughout The Innovation Process**

The typical innovative product or new technological development process has been described as a linear process in order to facilitate analysis, even though it is generally accepted that there are feedback loops, simultaneous activities and some overlapping of development stages (Piatier, 1984; Jelinek and Schoonhoven, 1990; Souder and Sherman, 1994). In considering the appropriateness of different approaches to the management of innovation there is some evidence that no single approach will be appropriate throughout all phases of the dynamic and changing innovation process.

The innovation process may be co-ordinated by a variety of mechanisms such as formal rules, plans, design reviews and inter-departmental teams (Adler, 1992), project managers as liaison officers (Hayes *et al.*, 1988) or committees (*ibid.*, 1988; John, 1985). Furthermore, co-ordination may be facilitated by the loose coupling of functions through

shared values, leadership and information technology systems in addition to multi-functional teams (Hitt *et al.*, 1993). Co-ordination may also be supported by the establishment of superordinate goals, the physical proximity and accessibility of project associates, guiding project team rules (Pinto *et al.*, 1993) and appropriate reward structures (*ibid.*, 1993; Hitt *et al.*, 1993).

Teams are not the only and most appropriate co-ordination mechanism and in general, the less interactive mechanisms may be preferable since more interactive methods can be time-consuming and more expensive (Adler, 1992), although teams may be essential for bigger projects. Participating departments experience different degrees of interdependence at different phases of the development process and for projects of varying technological complexity (*ibid.*, 1992). Teams or other integrating co-ordination mechanisms may be more necessary when projects are more innovative and have greater 'design analysability' concerns; since both circumstances reflect greater uncertainty in the match between product and process (*ibid.*, 1992) and teams may be the best way to achieve with these uncertainties. With greater innovation there is a requirement for more interactive co-ordination mechanisms and with greater design problems the co-ordination burden increases for the last phases of development (*ibid.*, 1992). Therefore greater levels of innovation may favour horizontal integration between all participating departments, whereas projects with greater 'design analysability' concerns may favour vertical integration with leadership from manufacturing departments.

'The widely recognised product-process-market stages suggest different emphases, different perspectives, different skills at different points in the innovation process' (Jelinek and Schoonhoven, 1990, p.317).

The early phase of the innovation process is characterised by uncertainty and ill-defined tasks (Twiss, 1992). This has led to some questioning of the application of organisation theory to innovation in early stages (*ibid.*, 1992). Twiss argued that the most important resource is human at this stage (Twiss, 1992) since what is really needed are good ideas, a good selection process for ideas and subsequent experimental or development work which may be difficult to plan and manage to timed deadlines. This is supported by previous research on cognitive style which suggests that unrestricted situations are necessary for creative ability to flower and benefit performance (McDonough III, 1990). Creativity therefore benefits the early inventive phase, particularly for more innovative projects (*ibid.*, 1990).



A front-end filter may separate the inventive phase from subsequent stages in the innovation process before which there is a free flow of information and beyond which formal processes of innovation management can operate (Jelinek and Schoonhoven, 1990). Typically, the team is formed at the point when the project begins to look technically feasible (Jelinek and Schoonhoven, 1990). Decentralised, informal, organic structures may be most appropriate at the early stages because mechanistic bureaucracies inhibit the freedom necessary to innovate although mechanistic bureaucracies are appropriate to the manufacturing stage since they control the large-scale operations needed for competition (Burns and Stalker, 1966; Jelinek and Schoonhoven, 1990). The requirement for different organisational forms at different phases addresses the dilemma for management inherent in the research finding that the formal design rules conducive to new product sales have inverse correlations with inventivity (Hull, 1990).

Several academics have suggested that organisational structures and the amount of cross-departmental interaction should reflect the needs of the innovation process (Hull, 1990; Twiss, 1992). This view is elucidated by a survey of 200 mostly large Japanese and US firms, although these findings represented only a 15% response rate which suggests that the survey results must be accepted only cautiously (Hull and Azumi, 1989). They argued that multi-functional integration is less necessary upstream when commercial applications are unclear (*ibid.*, 1989) and teamwork may be less important than creativity at the early phases (Hull, 1990). Furthermore, too much involvement of the marketing function at the interface between basic and applied research is counter-productive (Hull and Azumi, 1989). In addition it may be inappropriate to involve the research function at the post-commercial stage (*ibid.*, 1989). The value of the multi-functional team is highest mid-stream which is when divergent perspectives need to be assimilated during the transfer of upstream ideas down-stream (*ibid.*, 1989).

This work suggests that teamwork may be valuable throughout the innovation process but in different forms involving less multi-functional integration in the early and final phases. The work of Hull and Azumi supports the idea that the team as a quasi-structure may be an appropriate mechanism for managing both the informal early phase of the innovation process and adjusting to the more formal management requirements at the later stage (*ibid.*, 1989). However, existing research may suggest that even the team may be too formal and therefore inapplicable to the uncertain, unmanageable, early stages of innovation (See

Twiss, 1992). The importance of the multi-functional team is very complex (Jelinek and Schoonhoven, 1990) and varies over the innovation process.

#### **2.2.6. Hypothesis**

The implication of this review is that there are different types of organisational teams which reflect existent organisational structures and management systems bringing associated advantages and disadvantages to the innovation development process. When teams are employed with sequential management approaches and related organisational structures (See Table 2.2), they will be single-disciplinary in nature, whereas multi-functional teams will be associated with multi-departmental management approaches and related organisational structures (See Table 2.2), particularly matrix and venture management structures as well as multiple organisational structures.

In general, teams are differentiated by the extent and nature of the integration between the staff involved in the innovation process who may represent different disciplinary or business functional backgrounds. Furthermore, this review suggests that teams may be either fully integrated throughout the development process or partially integrated at key development transition points in innovation. There are suggestions that greater multi-functional integration is required mid-stream during the transfer of ideas to production and marketing. However, there is a need for more detailed information on the use and implementation of teams for the management of innovation projects.

**Hypothesis 1.** The management of innovation is associated with different organisational team approaches which are differentiated by the extent of the integration of departments, the diversity of staff backgrounds and the extent of integration during the development process.

### ***2.3. Appropriateness Of Multi-functional Teams To Developing Projects Of Varying Innovation***

The factors influencing the organisation and management of design and innovation are numerous including size of firm, level of technology employed, general management structures, type of product/service produced, company history, senior staff abilities and staff compatibility (Walsh *et al.*, 1992). This Section considers the significance of the level of project innovation as an influence on innovation management.

The idea that products and processes may vary in the level of technological innovation is generally accepted (Langrish *et al.*, 1972; Piatier, 1984; Hayes *et al.*, 1988; Rothwell, 1992). Section 4.8. presents academic views on how the level of technological innovation



may vary in Table 4.2. Attempts have been made to develop nominal scales to measure the level of innovation or the size of technical change which range from:

- zero change to the development of a new technology (Langrish *et al.*, 1972);
- radical novelty to old or traditional (Piatier, 1984);
- radical breakthrough to a mere improvement (Freeman, 1986).

Descriptions of exceptional novelty have included major innovation, radical innovation, breakthrough innovation, advanced technological innovation or basic innovation (Piatier, 1984). A range of incremental innovations lie between this and the non-innovative pole of the scale, such as novelty, design, improvement or upgrading, and combinations of old factors (Piatier, 1984). Similarly, in innovative product development, a new core product/process corresponds with the radical pole of innovation, whereas incremental product innovations include a range of innovations such as the next generation of core products, additions to the product family, enhancements and component changes (Hayes *et al.*, 1988; See also Johnes and Snelson, 1989 for similar distinctions between new and old product developments).

It is necessary to differentiate the development of a technological process from product innovation, since the development goals differ; the goal of new product development is customer sales, whereas the goal of R&D is the development of technology which may later be used in new product development (McDonough III, 1990). R&D project teams may be distinguished from new product development teams because they are more concerned with enhancing current technologies or developing new ones unlike new product development which is customer oriented (Barczak and Wilemon, 1991). However, the product process distinction should not be over-stated since R&D is likely to be required in product innovation, especially in more innovative product developments and technological processes are unlikely to be developed without the aim to provide some economic benefit, achieved through product or service developments. Furthermore, a product innovation for one company may become a process innovation for the user-buyer (Abernathy and Utterback, 1988). Accepting this, the management processes are seeking to optimise different goals in each case.

Section 2.2.3.2. has suggested that the management of technological innovation developments may require company innovation which can include hybrid or multi-structure

organisations which favour organic management principles. Organisation designs are more influenced by innovation which is closer to 'state of the art' (Twiss, 1992). This implies that the more innovative the project the more probable the requirement for new organisational approaches or management innovation. Furthermore, radical innovation developments need to be managed differently to incremental innovation developments. This view is supported by Rothwell '...while an incremental innovation might be introduced using existing structures and procedures, a radical technological innovation might, and frequently will, require concomitant and significant organisational and procedural adaptations if it is to be successful' (Rothwell, 1992, p.223).

Potter's research on design, development and manufacturing in large organisations such as Rolls Royce, British Rail and British Coal supports this view (Potter *et al.*, 1994). The research showed that radical innovation requires new organisational approaches which include greater networking and more interactive partnerships between buyers and suppliers than incremental projects developed in-house (*ibid.*, 1994). The implication is that incremental innovations pose fewer organisational challenges.

Johne's case study which compared the organisation of product innovation in more versus less innovative companies also supported the view that radical product innovation may require a radical change to the existing organisation structure where the innovative work is split off from the rest of the organisation in either a new venture team, group or department (Johne, 1985; See also Hayes *et al.*, 1988). However, the challenges of managing incremental developments cannot be dismissed as routine and Table 2.3. shows that both radical and incremental developments may be organised using a variety of alternative permanent and temporary organisational designs (Johne, 1985, See Table 2.3.).

Table 2.3. Principal Organisational Designs (Johne, 1985)

Organisation Designs	Permanent	Temporary
Designs suited for radical product innovation	New venture group/department	New venture team
Designs suited for incremental innovation	Standing new product committee	Temporary new product committee
	New product(s) department	Marketing department-led project team
	Marketing department	Technical department-led project team
	Technical department	Inter-department-led project team



Radical innovations benefit from managers who have an innovative problem-solving style and operate in an unrestricted climate without forced adherence to budgets and time schedules, both of which reduce the level of technological innovation and subsequent commercial success of the product (McDonough III, 1990). This is unlike incremental innovation which may be addressed within existing organisational structures or in temporary quasi-structures such as committees and teams (Johne, 1985) or a project management structure (Hayes *et al.*, 1988).

Further work involving 40 large companies supported these differences in the management of incremental or 'old product development' and radical product innovation called 'new product development' (Johne and Snelson, 1989). They recommended that old product development should be enshrined explicitly in organisational strategy, whereas new product development should be split off from normal organisational activities and headed by an intrapreneur (*ibid.*, 1989). Furthermore, although support by senior management is important for product developments generally, old product development may be managed by managers of low seniority, whereas new product developments requires leadership from senior management (*ibid.*, 1989).

### **2.3.1. Are Different Teams Appropriate To Radical And Incremental Innovations?**

It is interesting that John associated the use of teams with the development of both incremental and radical product innovations (Johne, 1985). In general, the potential of the team as a source of innovation (not specifically technological innovation) has been extensively researched (West and Farr, 1990). Noting the diversity of independent variables used to research the psychology of innovation and discerning a pattern, they argued that group level innovation is promoted by four factors (*ibid.*, 1990):

- a clear vision of a valued outcome which is shared by the team;
- participative safety where participation is encouraged in a non-threatening environment;
- a climate for excellence as reinforced by team evaluations, control systems and appraisals;
- an expectation of innovation as normal team behaviour (*ibid.*, 1990).

West and Farr argue that the factors of 'vision' and 'participative safety' particularly impact on quality of innovation whereas the factors of 'climate for excellence' and 'norms

for innovation' primarily influence the quantity of innovation (*ibid.*, 1990). Although both the bandwidth of this theory (that is, the comprehensive coverage of all influential factors), and the depth of specification of each factor are questionable, it lends psychological support to the use of teams as an instrument of innovation, both radical and incremental.

The Abernathy-Utterback model of the industrial innovation process supports the value of different types of groups for radical and incremental innovation developments. This model locates radical innovation at the early stages and incremental innovation at the end of the industrial innovation process (Abernathy and Utterback, 1988). The implications of this model for innovation management suggest that radical developments require co-ordination by a group tuned to techno-market uncertainties, whereas incremental innovation requires a more formally planned group focused on implementation with more hierarchical management layers (*ibid.*, 1988).

Another study of 40 large companies showed that multi-functional teams were appropriate to both old and new product development but in different forms (Johne and Snelson, 1989). In new product development these teams took the form of skeletal business teams operating outside the mainstream organisation, whereas old product development teams were influenced by in-house organisational structures, particularly the matrix structure (*ibid.*, 1989). Maccoby offered further support for the appropriateness of different types of teams to projects of varying innovation in a discussion of emerging new organisational forms, claiming that different team competencies are required in different technological and market circumstances (Maccoby, 1990):

- high-tech/standardised product markets - require a multi-skilled, non-hierarchical, self managed team where the team leader acts as facilitator;
- high-tech/customised product markets - require a heterarchy not a hierarchy where leadership of the team resides with the experts;
- low-tech/standardised products - require hierarchically structured teams;
- low-tech/customised products - require self managed teams which relate to customers and are coached by managers.

Standardised projects may require a greater ongoing input from marketing personnel than customised projects which are funded by clients from the outset, thereby emphasising the



relationship with the client not marketing activity. Furthermore, standardised projects entail a different relationship between design or R&D staff with production staff than customised projects which are one-off projects built for customers. The Maccoby typology also suggests the inappropriateness of a hierarchical team approach to high-tech, more radical projects, although this approach is appropriate to low-tech projects.

Further research comparing successful and unsuccessful innovating and operating (less innovative) teams in 57 companies (Barczak and Wilemon, 1991) supports the appropriateness of different types of multi-functional teams to projects of varying innovation. In general, teams were classified as operating or innovating, according to the degree of market newness, degree of product newness and degree of autonomy from everyday operating activities; innovating teams were characterised by loose controls, less formality, broad objectives and a long-term planning horizon, whereas operating teams worked on routine projects in typical markets and were more integrated with everyday business activities (*ibid.*, 1991).

Previous work had found a relationship between the level of project innovation and the nature of staff communication. More effective innovative projects required communication with more experts representing different disciplines, whereas routine projects were more effective when members communicated with more representatives of different functions, such as suppliers, vendors, customers etc. (Katz and Tushman, 1979).

Table 2.4. Barczak and Wilemon's Differences Between Operating And Innovating Teams

(Developed by Author)

Communication	Operating team leaders	Innovating team leaders
Communicate significantly more about	product features and schedules and involve customers, sales and vendors	customer needs and involve engineering
Less successful teams unlike more successful teams communicate significantly more with	customers, marketing and manufacturing about product specification issues	manufacturing and marketing
More successful teams unlike unsuccessful teams communicate significantly more about	technical issues, schedules & time-to-market with engineers, vendors, management, and purchasing	customer needs, engineering and technical issues and interact more with customers

Barczak and Wilemon's research findings also suggested that more innovative project teams communicated differently from operating teams and focused on different issues as Table 2.4. shows (Barczak and Wilemon, 1991). Effectiveness (as measured by

satisfaction with technological progress, commercial success, meeting budget and schedules and the projects' enhancement of the leader's career) depends on different types of skills for projects of varying innovation (*ibid.*, 1991).

The successful innovating team arguably needs to communicate less with manufacturing than the less successful innovating team because of fewer design problems (Barczak and Wilemon, 1991). It is interesting that less successful teams, both operating and innovating, communicate significantly more than successful teams with marketing, whereas successful teams communicate significantly more about technical issues than less successful teams. However there are differences between operating and innovating teams; unlike the operating team, the innovating project team arguably needs to communicate:

- more about customers' needs because they are trying to create a market;
- more with engineering because of the greater technological complexity of their project;
- less with customers, sales and vendors because they are further from markets, although discussion about customer needs is important and more successful innovating teams interact more with customers;
- less about schedules and time-to-market issues possibly because of the inventive, less manageable nature of the work which is further from market.

This exploratory research adopted a quantitative focus by counting hours spent in communication without specifying differences between innovation development phases. Related to the quantitative focus of the research, the researchers also theorised about the significance of more or less communication when more communication could reflect either good practice or greater problems in innovation. However, the research supports the influence of project innovation on team concerns and communication patterns. Different multi-functional expertise is required for the team effectiveness of innovating and operating teams. Furthermore, it found interesting significant differences between innovating and operating teams.

### **2.3.2. Are Multi-Functional Teams More Appropriate To Developing Radical Innovations Than Incremental Innovations?**

Greater multi-functional integration may be required for radical innovation developments since the Abernathy-Utterback model recognises that in the early more innovative stages of



an innovation cycle, the market is uncertain and production processes need to be developed to address the proliferation of performance requirements (Abernathy and Utterback, 1988). This later settles and the innovation process becomes incremental, thereby allowing for large-scale production and the development of capital-intensive production processes and R&D programmes (*ibid.*, 1988). Radical innovation has been described as 'competence destroying' by contrast with incremental innovation which is 'competence enhancing' because the latter unlike the former represent improvements in the price/performance characteristics of current products and build on existing know-how (Tushman and Anderson, 1986).

The greater value of multi-functional teams for developing radical innovation is supported by Rothwell's view that the management of radical innovations could include '...a specially formed and fully integrated project team whereas a less radical approach will generally suffice in the case of a product improvement project' (Rothwell, 1992, p.225). Shiner's study supports the association between radical innovation and the requirement for greater multi-functional integration in a study of ineffective relations between R&D and marketing in 5 high-tech firms, concluding that the greater the technological uncertainty and risk perceived by a firm, the greater the need for marketing and R&D integration (Shiner, 1992). Another study suggested that 'If the innovation is radical...there is likely to be a need for more intensive cross-functional interaction' (Pelled and Adler, 1994, p.25). Furthermore, the implications of Maccoby's research suggest that teams are appropriate in all technological and market circumstances, but that more technologically innovative projects particularly in standardised product markets, require less hierarchical multi-functional team approaches (Maccoby, 1990).

Johne and Snelson argue that multi-functional teams are appropriate to both new and old product development (Johne and Snelson 1989). However, the multi-functional integration required in old product development could also be achieved by regular, controlled contact and meeting a formal, documented system of objectives at critical stages of the development process (*ibid.*, 1989). This suggests that a multi-functional team approach is not essential for incremental developments.

However, there are also suggestions that multi-functional teams may not be appropriate to the development of radical innovation. Takeuchi and Nonaka admit that their recommendations for the implementation of self-organising teams may not apply to breakthrough revolutionary innovation (Takeuchi and Nonaka, 1986). Furthermore,

although multi-disciplinary teams may promote innovation through the association of technological concepts, they may not be relevant to technology transfer or the development of long-term technological capital to a detailed technical specification (Twiss, 1992).

By contrast, the value of multi-functional team for incremental innovation is evident in the best known studies which established the value of multi-functional team approaches for organisation performance. The most notable of these studies were wholly based on the automobile industry (Womack *et al.*, 1990; Clark and Fujimoto, 1991), a mature industry where competition is based on design and incremental innovation to support product quality, functionality, cost, aesthetics and fast time-to-market.

Further support for the value of the multi-functional team for incremental innovation comes from a survey mostly of large Japanese and US firms which suggested that radically inventive ideas depend more on creativity whereas incremental improvements depend on multi-functional team approaches for success (Hull and Azumi, 1989). However, there was a relationship between teamwork and inventivity in US companies but not Japanese companies (Hull and Azumi, 1989). Nevertheless, patents were used as a measure of inventivity in this study and while patents may be accepted as a measure of innovation in general, they are not necessarily indicative of radical innovation (*ibid.*, 1989). This complicates the research findings, although they suggest that patentable innovations, which are arguably more innovative than incremental improvements, depend more on individual creativity than teamwork. This finding excludes the US firms for which teamwork was an important correlate of inventivity.

### **2.3.3. Hypothesis**

There is support for the appropriateness of teams for both radical and incremental innovation developments. Much of the evidence suggests that different forms of management and different types of teams are appropriate to projects of varying levels of innovation (See Table 2.5. for a summary synthesis).



Table 2.5. Summary Of Requirements For Projects Of Varying Levels of project innovation

(Developed by Author)

Radical innovation	Incremental innovation
<b>Organisational approach</b> Requires new organisational approaches which includes networking and closer, interactive partnerships between buyers and suppliers (Potter <i>et al.</i> , 1994)	May be developed within existing structures (Rothwell, 1992; Potter <i>et al.</i> , 1994)
Projects are split off from rest of organisation within new venture teams or departments (Johne and Snelson, 1989)	May be organised by in-house departments, teams and committees (Johne and Snelson 1989)
Projects should operate outside restrictive budgetary or time constraints (McDonough III, 1990)	Requires formal management controls & documentation (Johne and Snelson 1989)
<b>Management</b> Requires innovative managers (McDonough III, 1990; Hull and Azumi, 1989).	
Requires leadership from senior managers (Johne and Snelson 1989)	Should be integral to organisational strategy and may be adequately managed by junior managers (Johne and Snelson 1989)
<b>Teams</b> Requires skeletal business teams (Johne and Snelson 1989) that are fully integrated (Rothwell, 1992)	
Requires project teams to be tuned to techno-market uncertainties (Abernathy and Utterback, 1988)	Requires a formally planned team with more hierarchical layers, focused on implementation (Abernathy and Utterback, 1988)
Requires non-hierarchical multi-skilled teams (Maccoby, 1990)	Requires hierarchical teams for standardised projects and self managed teams involving customers for customised projects (Maccoby, 1990)
Teams when successful communicate about customer needs, engineering and technical issues and interact more with customers (Barczak and Wilemon, 1991) & with different disciplines within the lab and external experts (Katz and Tushman 1979).	Teams when effective communicate with suppliers, vendors, customers (Katz and Tushman, 1979) & about technical issues, schedules & time-to-market with engineers, vendors, management, and purchasing (Barczak and Wilemon, 1991)
Requires loose controls, less formality, broad objectives with a long-term planning horizon (Barczak and Wilemon, 1991)	Should be integrated with everyday business activities (Barczak and Wilemon, 1991)

However, there are differences of view about the appropriateness of multi-functional teams to both incremental and radical innovations. Some researchers regard multi-functional teams as equally appropriate but in a different form (Johne and Snelson 1989; Barczak and Wilemon, 1991). A weight of opinion indicates that they will be more appropriate to radical innovations (Rothwell, 1992; Shiner, 1992; Maccoby, 1990; Pelled and Adler, 1994), although some academics think not (Takeuchi and Nonaka, 1986; Twiss, 1992). The appropriateness of multi-functional teams to radical innovation is particularly

questionable, when the aim is to develop long-term technological capital in markets where management is not optimised to address time pressures. Furthermore, despite different views, the value of the multi-functional team for incremental innovation is well established (Hull and Azumi, 1989; Womack *et al.*, 1990; Clark and Fujimoto, 1991). However, Adler's research suggests that the time and costs associated with a team approach may imply that team approaches are most appropriate to more innovative projects with greater problems in analyzing design problems (Adler, 1992).

**Hypothesis 2.** Although teams are appropriate to projects of varying levels of technological innovation, more innovative projects are associated with integrated team approaches.

## **2.4. Innovation Management And Firm Size**

Despite recognition of the economic importance of innovation, little has been established in the economic literature to identify those conditions conducive to innovation (Acs and Audretsch, 1991). Furthermore, evidence to support the role of the new technology-based small and medium-sized enterprises (SME) in the innovation process is still sparse (Rothwell, 1994), although most Governments in advanced market economies have devised measures to support the SME (Rothwell, 1989). An economic analysis of technological innovation led Schumpeter to emphasise the importance of both market structure and firm size as the key instrument of technological innovation (Schumpeter, 1950). In his earlier career in the 1930's, Schumpeter saw the small-scale entrepreneur as the key to capitalism's vitality, whereas later in the 1940's he argued that the large-scale enterprise was the principle vehicle for technological progress and its consequent economic impact (*ibid.*, 1934; 1950).

In the ensuing discussion, the significance of firm size for innovation management should be tempered by the following points:

**First**, definitions of the small firm vary amongst academics from sector to sector and between policy initiatives; however, most are based on the number of employees, although small firms may be classified by a turnover of between 1 million and 5 million pounds sterling (Rothwell and Zegveld 1982; Slatter, 1992). The small firm has usually less than 500 employees (Rothwell and Zegveld, 1982) and the size accepted is usually between 50-150 employees (Slatter, 1992). The upper limit may now be considered quite large with the impact of work-based technologies on company size in a climate of the down-sizing company. Slatter argues that quantitative measures are not sufficient indicators of firm size, since there are organisational characteristics typical of small firms, such as the



entrepreneurial influence of the founders and the lack of both financial and human resources (*ibid.*, 1992).

**Second**, the small firm is frequently classified with medium-sized firms or SME's (e.g. Rothwell, 1994).

**Third**, the SME concept is not limited to independent SME's since larger firms may install smaller units and new venture departments. Instead of the advantages of small firms, Yeaple discusses small R&D *organisations* which are arguably more productive than large firms; this includes team approaches in companies like IBM and MacIntosh (Yeaple, 1992).

**Fourth**, firm size implications may be obscured by collaborations of varying interdependency and dependency between firms which do not operate in environmental isolation; Rothwell draws attention to possible complementarities between firms (Rothwell, 1989) and organisational networking has been afforded recent importance in research on successful innovation (Rothwell, 1992). These points elucidate some obscurities in the investigations of the influence of firm size on technological innovation.

As a result of assumed economies-of-scale for innovative outputs Schumpeter argued that large firms have an inherent advantage in innovative activity as a result of monopoly power (Schumpeter, 1950). In considering the question of why innovating firms fail to accrue significant economic returns from innovation, Teece suggested that when imitation is easy and development costs are high, profits accrue to owners of complementary assets such as marketing and manufacturing capabilities, which are usually held by the large firm (Teece, 1986). Furthermore, the biggest contribution from small firms is in sectors where capital and R&D entry costs are relatively modest and where market segmentation is high (Rothwell, 1989). The smaller firm and independent innovator may be disadvantaged in many markets due to:

- their lack of access to complementary assets and even with strategic contractual partnering they risk competition from partners (Teece, 1986);
- the imitability and development costs associated with innovation which lead to opportunities for scale economies favouring the larger firm (*ibid.*, 1986);

- the greater probability that technical and legal regimes of ‘appropriability’ will be loose, particularly relating to the property rights environment, thus adversely affecting the ability of the innovator in small firms to capture profits (*ibid.*, 1986);
- their fragility (Slatter, 1992) and poor ability to accommodate high risks (Rothwell and Zegveld, 1982).

Despite such disadvantages and the scarcity of evidence, technological-based SME’s have been credited with a key role in developing technological innovation (Jewkes *et al.*, 1969; Rothwell, 1994). In a review of the origins of 61 major 20th century inventions 36 (59%) came from independent inventors and only 12 (41%) from large firms (Jewkes *et al.*, 1969). Furthermore, an analysis of existing databases show that small firms have approximately 2.4 times more innovations per employee than large firms (Acs and Audretsch, 1991). However, both large and small firms have respective advantages with varied contributions to the innovation process in different sectors (Rothwell, 1989). This is evident in a review of 2,300 important innovations between 1945-1980 introduced in the UK which showed that at an aggregate level, SME’s contributed only about 20% of these innovations and the contribution of larger firms was increasing as a result of embracing small firm management practices through reorganisation in smaller units (Townsend *et al.*, 1981).

Furthermore, the small firm may be more associated with the genesis of radical innovations than large firms, since unconstrained by existing techno/market regimes they are better able to exploit new techno/market opportunities (Rothwell, 1989). Many advances in technology arise from the accumulation of detailed inventions which are less likely to take place in a giant corporation than in the small firm because of the niche markets pursued by the smaller firm (Acs and Audretsch, 1991). The Abernathy-Utterback model of the industrial innovation process in mass markets associates radical innovation with small firm activity and incremental innovation with mature businesses, but at different phases in the industrial innovation process (Abernathy and Utterback, 1988; Rothwell, 1989). Smaller firms play a significant role in innovation in the earlier phase of a technology while larger firms dominate the later stage of the technology’s life-cycle with incremental innovation, where economies of scale become important particularly in mass markets (Rothwell and Zegveld, 1982). Rothwell and Zegveld conclude:



‘Technological change is best promoted in a system that utilises the potential symbiosis between small and large firms, which derives from the fact that the former are particularly adept at radical innovations while only the latter have sufficient resources for successful large-scale development’ (Rothwell and Zegveld 1982, p.4).

Two key phases are distinguished in the Abernathy-Utterback model of the process of industrial innovation (Abernathy and Utterback, 1988):

1. the pre-paradigmatic stage which is characterised by more radical innovation with competition on design and product innovation, loose adaptive manufacturing processes and a greater preponderance of small entrepreneurial firms.
2. the paradigmatic stage which is characterised by more incremental innovation following the emergence of a dominant design leading to greater competition on price than design. Outside niche markets this is a more favourable climate for large firms since price competition is helped by process innovation leading to an increase in production volumes and opportunities for economies-of-scale (*ibid.*, 1988). As the innovation process matures the small firm may either grow or die.

Rothwell claims that there are certain features of small and medium enterprises (SME’s) which make them inherently more innovative than larger firms (Rothwell, 1994). Table 2.6. outlines these differences with supportive research findings.

Table 2.6. Advantages of Small Enterprises

(Developed by Author)

Small Enterprise Advantages Over Large Firms	Small Enterprise Characteristics
<p><b>Market responsiveness</b> Although large firms have a high degree of marketing power and comprehensive distribution facilities, they may be slow and undynamic (Rothwell, 1989). Designed for stability in products, processes and markets, they tend to be inwardly oriented, inattentive to external change (Rothwell, 1994) and resistant to incremental change (Jelinek and Littler, 1994).</p>	<p>Small firms have the capability to respond to the market with greater dynamism, responsiveness &amp; flexibility to market shifts than the larger firm (Rothwell and Zegveld 1982; Yeaple, 1992; Rothwell, 1994) They are more closely coupled with the market and less dependant on formal market research due to closeness to the customer (Yeaple, 1992). Since formal market research tends to be biased against innovation, this leads to greater innovation in the smaller firm (<i>ibid.</i>, 1992).</p>

Table 2.6. *Continued.*

Small Enterprise Advantages Over Large Firms	Small Enterprise Characteristics
<p><b><u>Entrepreneurial Environment</u></b>            Although large firms have strategic capability, they may be risk adverse, bureaucratic and undynamic (Rothwell, 1994). Large firms are traditionally mechanistic with slow decision making and isolated functional groups (Rothwell, 1994). Bureaucratisation in the innovation process inhibits inventiveness and slows down the pace at which new inventions move through the corporate system (Link and Rees, 1991).</p>	<p>Small firms are characterised by an entrepreneurial environment (Rothwell and Zegveld, 1982), entrepreneurial management, an organic style, rapid decision making, risk taking (Rothwell, 1994), greater opportunism, less rigid planning (Yeaple, 1992; Slatter, 1992), strong entrepreneurial influence of founder(s) (Slatter, 1992) little bureaucracy (Yeaple, 1992; Rothwell, 1994) greater staff integration (Rothwell 1994) and improved co-ordination of innovation developments both within and between organisations (Cooper, 1964).</p>
<p><b><u>Effective Communication And Networking</u></b>            As the firm grows, it is difficult to maintain team spirit, since the number of relationships and management levels increase, leading to greater formality and communication difficulties (Slatter 1992, p.143). This can lead to slow reaction to threats and opportunities (Rothwell, 1989).</p>	<p>Small firms are characterised by good communication (Rothwell, 1994; Cooper, 1964) which is efficient and informal (Rothwell, 1989). Smaller interpersonal distances facilitate communication and avoid time-wastage associated with trying to contact people (Yeaple 1992). This leads to fast problem-solving, adaptability and business reorganisation when necessary (Rothwell, 1989).            Although large firms are able to access scientific and technological expertise and small firms may lack the resources to do this (Rothwell, 1989) small firms were found to be more efficient at exploiting university based associations (Link and Rees, 1991).</p>
<p><b><u>Higher technical competence</u></b>            The cause of poor utilisation of technological resources in larger firms is organisational (Jelinek and Littler, 1994). It is a paradox that the larger firm can attract highly skilled technological staff and resources (<i>Ibid.</i>, 1994)</p>	<p>Although small firms may have staff recruitment and retention difficulties (Rothwell, 1989; Caird, 1992), they have higher technical competence (Cooper, 1964).</p>
<p><b><u>Cost Effectiveness</u></b></p>	<p>Although the large firm commands greater financial resources, has a greater ability to spread risk and benefit from economies-of-scale (Rothwell, 1989), the small firm has a greater concern with costs (Cooper, 1964). In the UK the Bolton Committee concluded that small firms contributed 10% of all industrial innovations while accounting for only 5% of R&amp;D expenditure (Freeman, 1971).</p>

However, the advantages of the larger firm include greater technological and financial resources (Rothwell, 1994). Slatter summarises the significance of firm size as follows 'In short, the advantages of large firms are mainly material while the advantages of small firms



are mainly behavioural' (Slatter, 1992, p.16). Many larger firms have attempted to capture these advantages by emulating small firm practices through the use of organisational designs such as the venture management structure which was widely adopted in 1960's and early 1970's (Johne, 1985).

Problems with bureaucracy, integration of effort and flexibility in operating extra-organisationally suggest that the multi-functional team approach would be particularly appropriate to the larger enterprise. Indeed the most well-known research on multi-functional teams was wholly based on the automobile industry (Womack *et al.*, 1990; Clark and Fujimoto, 1991) which is dominated by large firms. Other studies which have established the value of multi-functional team approaches in terms of performance outcomes have used case studies and observations of large, often well-known companies (Riedel and Pawar, 1991; Takeuchi and Nonaka, 1986; Yeaple, 1992). These combined studies would suggest that multi-functional team approaches should be appropriate to developing incremental innovations, particularly in large firms.

The appropriateness of multi-functional team approaches to the smaller firm context is less clear. The emphasis on the organic organisation and entrepreneurial management style in the small firm would suggest that small firms use team approaches informally, since teams may easily emerge within an organic management system. Nevertheless, an organic management system does not necessarily lead to the use of teams; indeed Burns and Stalker never mentioned team use as a characteristic of the organic management system (Burns and Stalker, 1966). However, there is evidence of team use in small innovative firms (Eisenhardt and Schoonhoven, 1990). Since informality characterises the small firm environment then team use is likely to be informal.

It is noteworthy that although teams may be quasi-structures and often temporary (Johne, 1985; Jelinek and Schoonhoven, 1990), they are not necessarily informal. The multi-functional team as discussed in Sections 2.2.3.2. has both organic attributes in addition to more formal attributes which pertain to recommendations for overlapping innovation phases, integrating team efforts (Takeuchi and Nonaka, 1986) and for the management of project developments which vary in both the level of technological innovation and market focus (Johne and Snelson, 1989; Hull and Azumi, 1989; Maccoby, 1990).

It is arguable that the small firm would benefit little from a more formally organised team approach, such as the multi-functional team. It is mainly, but not exclusively, large

companies that develop mechanistic structures, since the requirement for clarity in structure grows in relation to the size of the company (Jelinek and Schoonhoven, 1990). Mechanistic structures can inhibit in-house innovation and entrepreneurship (Rothwell, 1992). Table 2.6. suggests that communication, co-ordination and staff integration are less a problem for the smaller firm than for the large firm. Furthermore, the small firms' greater market responsiveness may suggest that products are quick to market or to clients (Table 2.6.) and therefore do not have the same problems as the large firm.

Furthermore, the small firm is characterised by internal fragility with respect to both financial and human resources, and by extra-organisational fragility as a result of volatile markets (Slatter, 1992). Human resource limitations such as recruitment and retention problems (Rothwell and Zegveld, 1982; Caird, 1992) may lead to multi-tasking behaviours and some difficulties in maintaining teams. Furthermore, the time required to set up an integrated team approach can be a drawback (Jelinek and Schoonhoven, 1990) in a small firm strapped for resources. This suggests that multi-functional teams which arise in the small firm would be more probably composed of a multi-tasking and changing membership which is distinct to the multi-functional team concept involving the integration of diverse functional staff expertise.

However, the following points may support the benefits of multi-functional teams for solving some small firm problems. Small firm managers often lack formal management skills and have problems with external communication (Rothwell, 1994). Furthermore, 'would-be innovators' tend not to develop a balanced business plan which integrates the requirements for technological development with marketing and tend not to create sustaining business structures (Livesay *et al.*, 1989). Slatter attributes importance to effective co-ordination at the interfaces between marketing, operations, engineering and R&D; indeed one of characteristics of high-tech firms in trouble is a plethora of operating problems relating to critical boundary issues at these interfaces (Slatter, 1992). More generally, team approaches may alleviate the dependency of the small firm on the owner-manager which strongly influences the performance of small firms (Rothwell and Zegveld, 1982).

However, if the key disadvantage of the large firm is behavioural by contrast with the small firm which is primarily disadvantaged by lack of material and human resources (Rothwell and Zegveld, 1982; Slatter, 1992; Caird, 1992), then although the multi-functional team may be appropriate to all firms, the key problems of smaller firms may not be addressed by



this team approach. The author found in a study of government-sponsored small firm innovators that the most frequently cited factor affecting the progress of innovative development projects was the need to establish technical viability and the most frequently cited problem was the problem of recruiting and retaining relevant staff expertise (Caird, 1992). Other key problems included securing financial backing, gaining market acceptance and securing partnerships with other companies (*ibid.*, 1992). A later study, by the author and other researchers, with innovators competing for the Environment Award for Engineers, showed that a group of mostly small business owner-managers experienced marketing problems as the most important problem in innovation (Caird *et al.*, 1994).

While it is arguable that a multi-functional team approach may support the establishment of technical viability in addition to extra-organisational operations, the idea that teams offer the panacea for the financial, marketing and staffing problems which characterise the small firm is unconvincing. Of course this applies to the larger firm too and it is noteworthy that for would-be innovators from companies of all sizes the most frequently experienced and most important problems are those concerned with securing financial backing and establishing technical viability, both of which can only be partially addressed by a multi-functional team approach (Caird *et al.*, 1994). Nevertheless there is a weight of evidence supporting the greater technological and financial resources of the larger firm (Slatter, 1992; Rothwell, 1994) and the appropriateness of a multi-functional team approach to innovation (Takeuchi and Nonaka, 1986; Womack *et al.*, 1990; Clark and Fujimoto, 1991; Riedel and Pawar 1991; Yeaple, 1992). In the small firm inter-functional integration may be more easily accomplished by an informal multi-functional team approach which naturally arises. However, small firm management may be optimised to address more significant small firm problems, such as financial, marketing, marketing and human resource related problems, even though problems with co-ordination characterise the small high-tech firm in trouble (Slatter, 1992).

#### **2.4.1. Hypothesis**

The literature suggests that multi-functional teams are appropriate to large firms involved with innovation developments, although the appropriateness of multi-functional teams to medium and small firms requires exploration. It is likely that small firms will informally adopt multi-functional team approaches but in a different form to the large firm. In the small firm, multi-functional teams may be characterised by a multi-tasking, changing membership where the pressures of time and human resource problems such as retention,

dissuade companies from investing in formal integration efforts. This may be different to the ideal multi-functional team which integrates expert staff with different functional backgrounds.

The benefits of multi-functional team approaches may come from informal aspects of the concept for the large company and from the more formal aspects for the smaller company. However, multi-functional teams may address important large firm problems, such as integration, to a greater extent than important small firm problems. Furthermore, it is clear that multi-functional teams can only partially address company problems with innovation developments for companies of all size.

Although the SME acronym has been bandied about in the literature, it remains unclear if medium-sized companies share the characteristics and limitations of the small firm; it is unlikely that resources are as limited in the medium-sized firm nor the organisational approach as informal as in the small firm organisation. Further exploration of the significance of firm size for innovation management is required with the recognition that company size differences may be obscured by both definitional differences in size bands and the new trends towards inter-company networks and alliances.

**Hypothesis 3.** Multi-functional teams are appropriate to large firms involved with innovation developments. It is likely that small firms will informally adopt multi-functional teams. The appropriateness of multi-functional teams to medium-sized as well as inter-company collaborative projects requires exploration.

## ***2.5. Impact Of Complex Team Processes On Effectiveness***

Recommendations to adopt team approaches in innovation seldom refer to group theories and team research which both reveal the complexity of group dynamics, the difficulties in achieving effectiveness and the numerous factors which influence team processes, team effectiveness and their organisational impact. 'Cross-functional project teams, however prevalent, do not guarantee effective development.' (Hayes *et al.*, 1988, p.105).

Furthermore, high-performing teams are extremely rare because of the high degree of interpersonal commitment required and the greater preference for individual not collective accountability. Nevertheless companies with strong performance standards seemed to spawn high-performing teams (Katzenbach and Smith, 1993). Clearly, the team requires successful management (Susman and Dean, 1992). According to Handy, although there is a need to co-ordinate the expertise of individual in groups, a proper understanding of groups demonstrates how difficult they are to manage (Handy, 1993).



Investigations of the impact of teams on innovation are limited if intra- or inter-company comparisons ignore the moderating effect of team effectiveness on outcomes. Team operations cannot be understood by simply observing the presence or absence of a team approach within an organisation as if team use is a fixed input in the innovation process. The crude exploration of team processes as an independent variable in innovation success studies is evident in Bursic's investigation of which strategic factors contributed to the successful use of teams in a single large manufacturing organisation (Bursic, 1992). By comparing the impact of members' participation in teams using measures of productivity, quality, satisfaction, motivation, decision-making through interviews, self reports and other output measures, no significant results were found (*ibid.*, 1992).

However, members' participation in teams were rated according to the number of teams they were involved with and not with a more qualitative measure of team processes. In this way, team processes were ignored and the quantitative focus betrayed an unjustified assumption that participation in a greater number of teams should be associated with greater benefits. Without empirical support resulting from this quantitative focus or detailed attention to team processes, Bursic went on to argue that successful strategies for team use included top management support, a defining leadership, using a facilitator, provision of clear objectives and goals, early planning, inter-disciplinary teams, a defined team structure, using team building, training in problem-solving and measuring team results (Bursic, 1992). In the innovation literature, greater attention is given to the team as a management approach and typically little information is provided on how teams operate successfully (See Clark and Fujimoto, 1991).

### **2.5.1. Contribution Of Group Theories**

There are numerous group theories or models available to elucidate group processes and effectiveness. In a recent non-statistical study of large companies like Motorola and 3M, Katzenbach and Smith proposed a Team Performance Model which rated teams along performance and effectiveness axis leading to the differentiation of high-performing from low-performing groups and teams (Katzenbach and Smith, 1993). Non-statistical findings support this model and suggest that important antecedent conditions for high team performance include members with complementary skills, shared goals, collective accountability, a social dimension and a deep commitment to each team member's personal growth and success (*ibid.*, 1993).

However, the model is very crude with a poor definition of the concepts of effectiveness and performance which are represented as continua with indistinct axis points. Furthermore, no account is given of the significance of the project or factors external to the team for team performance. The non-specificity of measures in this model, its inherent prescriptiveness and poor explanatory and predictive power suggests that it would not account for the complexity of the relationship between effectiveness in team processes and performance outcomes.

The group psychology literature appears to offer more insight into group processes. Group theories tend to be presented in a flowchart form with variables expressed in terms of direction rather than in terms of functional relationships with weightings given to the group variables. The majority of theories recognise antecedent conditions which impact on effectiveness (Goodman *et al.*, 1986). The Model Of Task Group Effectiveness represents a dynamic model which recognises both group-level and organisational-level inputs to the group process and importantly acknowledges that effectiveness is influenced by characteristics of the task which include complexity, interdependence and environmental uncertainty (Gladstein, 1984). The Sociotechnical Model represents another dynamic but untested model which identifies feedback loops from group outcomes to organisational leadership which in turn impacts on organisational arrangements which impact on group processes (Trist *et al.*, 1977); a useful model for considering organisational change arising from team outcomes. Hackman's Model of Work Team Effectiveness notes the importance of both organisational and group conditions for effectiveness, including material resources and group synergy which facilitate the enhancement of team effectiveness (Hackman, 1990).

Few theories attend to the significance of the wider environment for group processes in any depth. The Homans model suggests that groups should be viewed within a system of escalating cycles of interaction between groups and their environment. The internal group system has three interdependent elements of activity, interaction and sentiment which also are interdependent with the external system, so that changes in one system affects all and complexity in the environment generates a cycle of complexity in group processes (Homans, 1950). Lewin's theory also elucidates group interactions with the environment since although groups are constrained by their environment, they help to create their environments through the permeability of their boundaries (Lewin, 1951).



Other theories emphasise the important role of time and development in group processes as teams develop from forming to performing phases (See Tuckman and Jensen, 1977). This is important since antecedent conditions do not have an instantaneous effect on team outcomes and team performance rises with the length of the team's existence, although it falls after a 2-4 year period of existence (Katz and Allen, 1982).

The problem with group theories refers to the complexity of their components which mount into untestable complexity when inter-relationships and influences are added. Although each theory identifies some similar components, they are frequently named slightly differently or described differently. For example, the Hackman theory recognises the importance of *organisational context*, whereas the Gladstein theory discusses *organisational level and structure* and the Trist model recognises *organisational arrangements* as an influence on team processes (Hackman, 1990; Gladstein, 1984; Trist *et al.*, 1977).

There is a trend towards systems approaches to research on group processes. 'Complex relationships between variables exist in the real world and the only way to get at these complexities is to study systems of variables, rather than 2 or 3 variables at one time' (Goodman *et al.*, 1986, p.22). However, this can also be associated less conceptual clarity which adds to the difficulty of:

- identifying critical variables;
- separating variables for testing;
- understanding the interrelationships among variables;
- making predictions;
- making team building interventions.

The theories are not fully empirically validated and there is a gulf between theory and research with research frequently divorced from a theoretical framework. According to Goodman *et al* '...the very general specification of these models precludes assessing the models' validity' (Goodman *et al.*, 1986, p.12). They add that there is a need to:

- develop fine-grained testable models which offer a better conceptualisation of components;

- specify clearer functional relationships;
- account for multi-directional relationships;
- use clear measures;
- identify theoretical generalisability;
- consider the role of time in group development (*ibid.*, 1986).

### 2.5.2. Group Processes And Effectiveness

By compiling information on important group processes which impact on effectiveness from these theories (Trist *et al.*, 1977; Hackman, 1990; Gladstein, 1984; Katzenbach and Smith, 1993) the following interrelated variables can be identified as having an impact on team processes through the development stages as well as the team outcomes:

- membership variables, such as the size of the group, team member composition including competency, functional group representation and expertise;
- task variables, such as strategy, tasks, project goals and objectives;
- interaction variables over the development cycle, such as cohesiveness, trust, team roles, leadership, communication networks, norms and inter-group relationships;
- environment variables, including external relations both intra-organisational and inter-organisational, the organisational context and the external or socio-economic environment.

It is arguable that complex interrelated group processes impact on team effectiveness. However, the concept of team effectiveness can be obscured by failures to distinguish effectiveness in group processes from the measurement of effectiveness outcomes. The relationship between effective group processes and success outcomes is not clear. Woodcock describes team effectiveness prescriptively in terms of a set of effective group characteristics as if the summation of these prescriptions leads to positive project outcomes (Woodcock, 1989). Other academics have attempted to separate observations of team processes from outcome measurement to support insights into team processes which are conducive to effectiveness. For example, team effectiveness is measured by outcomes,



including task accomplishment, team interaction and team satisfaction (Adair, 1983). This has similarities to Hackman's definition of effectiveness in terms of whether:

- the group output meets or exceeds organisational standards of quality, quantity and timeliness;
- the process contributes to the growth and personal well-being of members;
- the process enhances the capability of members to work together in future projects (Hackman, 1990).

#### *2.5.2.1. Membership Variables*

The importance of membership is evident since 'The decision on group membership serves to define the resources the team possesses and those that must be acquired externally' (Ancona and Caldwell, 1987, p.206). The team should be small and comprised of members who possess relevant complementary competencies (Woodcock, 1989; Katzenbach and Smith, 1993). Research with a large sample of computer executives also found that small department size had an important positive influence on performance <sup>2</sup> (Ford and McLoughlin, 1992).

However, team prescriptions can obscure the complex impacts of team characteristics on both group processes and team effectiveness. The significance of size illustrates the holistic impact of group characteristics on group processes. The bigger the team the greater the:

- problems in management and communication;
- opportunities for interpersonal conflict;
- demands on leadership;
- social distance between leaders and members;
- tolerance of direction by leaders among members;

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<sup>2</sup> Performance was measured by meeting cost expectations, meeting time deadlines, the utilisation of technological expertise and working effectively within the organisation.

- domination of group interaction by a few members;
- inhibition in member participation;
- requirement for team competency and clarity of roles;
- time taken to reach decisions;
- formalisation of rules and procedures;
- tendency for sub-groups to form within the team (Hellriegel *et al.*, 1989).

Furthermore, team prescriptions can obscure the probability that team characteristics have differential impacts which is illustrated by research on member characteristics. Member characteristics may be expressed in terms of the tenure or functional heterogeneity of members. The value of tenure homogeneity, where the team members join the organisation at the same time, is that it supports similarity in understanding and cohesiveness. Previous research has shown that internal processes such as goal clarification and team-rated performance benefit from this, although tenure homogeneity has a negative impact on team adherence to budget and schedule (See Ancona and Caldwell, 1992). Functional diversity or heterogeneity within teams refers to a membership which represents different expertise and performs different functions. Like tenure homogeneity, functional diversity has differential impacts on team processes and effectiveness. This characteristic of teams is of particular interest to this research on multi-functional teams and is therefore discussed separately (See Section 2.5.3.)

#### **2.5.2.2. Interaction Variables**

The effective team has members who share responsibilities, play complementary roles and can tolerate conflict and deviation (Woodcock, 1989). It requires an open, co-operative communication network (*ibid.*, 1989) which supports real-time problem-solving (Katzenbach and Smith, 1993). Furthermore, it requires an appropriate leadership which:

- is concerned about relationships and the needs of individual members (*ibid.*, 1989);
- maximises the use of members' talents and competencies, (*ibid.*, 1989);
- establishes appropriate procedures for operations (*ibid.*);
- is participative where possible (*ibid.*);



- is democratic and focused on early resolution of conflicts (Hayes *et al.*, 1988);
- supports integration through the principle that ‘...teamwork requires equality of status’ (Hayes *et al.*, 1988, p.261);
- performs roles such as communication, climate setting, planning and interfacing (Barczak and Wilemon, 1989);
- is appropriate to the level of project innovation; leaders of new technology projects should have an innovative problem-solving style, whereas applications projects benefit from ambitious leaders and minor modifications projects benefit from leaders with a cosmopolitan orientation (McDonough III, 1990).

In addition to required competencies, team effectiveness arguably depends on the performance of certain team roles. Team roles and behaviours may be classified as beneficial such as task-oriented and relations-oriented behaviours which serve to maintain the team for goal-achievement, or potentially damaging such as self-oriented behaviours which can include manipulation, attention-seeking, domination, resistance or withdrawal in group interactions (Bales, 1950). Belbin took the topic of team roles further by identifying the importance of individual differences, both strengths and allowable weaknesses in team members; these roles together with team member analytical abilities were arguably important for effectiveness (*ibid.*, 1981). Three roles in Belbin’s typology may be identified as entrepreneurial and innovative, that is the Shaper, Resource Investigator and Plant Roles <sup>3</sup> (*ibid.*, 1981). Madique has identified the corresponding roles of entrepreneur and project champion, technological gatekeeper and innovator as crucial for innovation success in firms of all sizes (Madique, 1988).

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<sup>3</sup> The Shaper (SH) - This is the more manipulative, ambitious, entrepreneurial, opportunistic face of team leadership. The SH makes things happen and shapes the team efforts through establishing objectives and priorities and may resort to illicit or immoral tactics.

The Plant (PL) - This is the introverted, intelligent, innovative member. The PL attempts to advance new ideas and strategies.

The Resource Investigator (RI) - This is the extroverted, resource gathering face of the innovator. The RI explores and reports on ideas, resources and new developments which occur outside the team. The RI is a natural at public relations and networking and creates useful external contacts for the team.

### 2.5.2.3. Task Variables

The effective team has a strong task focus and goals are shared by all team members who are equally committed and collectively accountable (Trist *et al.*, 1977; Woodcock, 1989; Katzenbach and Smith, 1993) for goals established early on (Hayes *et al.*, 1988). Task complexity moderates the impact of group processes on project outcomes (Gladstein, 1984). In addition to the different implications of radical and incremental innovation for innovation management noted in Table 2.5, greater technological complexity is associated with greater conflict because of task pressures, the requirement for cross-functional integration, resource scarcity and time-to-market pressures (Pelled and Adler, 1994). Greater technological complexity is also associated with less successful outcomes (Schewe, 1994). This suggests that team effectiveness may not be associated with greater success when projects are more innovative and the management challenge is greater with such projects.

### 2.5.2.4. Environment Variables

The effective team co-operates with other groups, which may be from within the organisation or drawn from several companies, to work on projects relevant to the organisation's strategy with flexibility to challenges and opportunities in the external environment (Woodcock, 1989). High-performing teams revise knowledge of the environment continually, initiate programs with outsiders and promote the team's achievements in the organisation (Ancona, 1990). Effectiveness in managing the external environment may be of critical importance for the success of new product/process development teams (Ancona and Caldwell, 1987) and this has often been underplayed in group process studies (Ancona, 1992). External relations are more effective when certain information processing roles are performed (Ancona and Caldwell, 1987); these roles relate to the requirement for generating ideas, promoting ideas, winning support and protecting the team (Table 2.7).

Table 2.7. Ancona And Caldwell's Boundary Spanning Roles

(Developed by Author)

Roles	Information flows in	Information flows out
Initiated within team	<b>Scout</b> - brings in information as technological gatekeeper or resource investigator	<b>Ambassador</b> - project champion who presents team to organisation
Initiated outside group	<b>Sentry</b> - filters inputs	<b>Guard</b> - responds to requests for information



Findings from interviews with team leaders suggested that the amount and type of boundary spanning activity is critical for success, but the importance of specific roles change over time; the scout and ambassador roles are more important in the early stages and the guard and sentry roles are more relevant to the development phase when team permeability needs to be reduced and cohesiveness enhanced, until again the ambassador role is important for the diffusion phase (Ancona and Caldwell, 1987). The literature suggests an inverse relationship between internal and external activities in terms of performance. More effective external relations were associated with poor cohesion but good performance and less effective external relations were associated with poor performance (Ancona, 1992). Research findings show that, while effectiveness in internal group processes predicted team member satisfaction and team ratings of performance, effectiveness in external relations predicted sales revenue (*ibid.*, 1992). Effective external relations are of paramount importance for project success outcomes.

### **2.5.3. Impacts Of Multi-Functional Membership In Teams**

Functional diversity in team membership leads to conflict which has some favourable effects, such as better problem solutions, greater productivity, less group-think, enhanced decision-making and some unfavourable effects, such as decreased performance, higher staff turnover and withdrawal (Pelled and Adler, 1994). Teams of people from different thought worlds may find it difficult to develop group cohesiveness and a shared purpose (Ancona and Caldwell, 1992). Furthermore, functionally diverse teams are more visible in the organisational environment since they often come from different departments, which opens them to political and goal conflicts (*ibid.*, 1992). Another problem associated with functional diversity is disharmony in communications; Souder reports that 60% of new product/process development teams report communication disharmony (Souder, 1988). However, disharmonious group relations may not be a problem for group outcomes and a study of 14 project teams suggested that groups with high harmony may be less productive than groups with less trusting members since high harmony may reduce group task orientation (Brown *et al.*, 1990).

More positively, a study of 45 new product development teams found that the greater the functional diversity, the more team members communicated cross-functionally and cross-boundaries and the more innovative the team's work was likely to be perceived by management (Ancona and Caldwell, 1992). On the other hand, the overall effects of diversity on performance was negative and it appeared that more homogeneous teams find

teamwork easier. However, the researchers admit that the interference of extraneous variables in these results is likely, since this study fails to account for other factors which affect outcomes, such as size, task resources and so on (*ibid.*, 1992).

In a study of five multi-functional teams, Pelled and Adler elucidated the differential impacts of functional diversity on team processes and effectiveness. They argued that functional diversity creates conflict because it triggers anxiety and a selective perception by team members to information relevant to their own departments or functions (Pelled and Adler, 1994). The favourability of the impact of functional diversity may depend on whether the conflict is primarily task-based or emotional in nature, the former being functional and the latter dysfunctional (*ibid.*, 1994).

However, the negative influence of functional diversity on conflict may be ameliorated by team-based moderators, such as member longevity, team building and task complexities and uncertainties which can bring diverse staff together. Negative influences may also be ameliorated by organisation-based moderators, such as goal-orientation, the reward structure, physical proximity of members and their technical expertise (Pelled and Adler, 1994).

Table 2.8. Favourable and Unfavourable Effects of Functional Diversity

(Developed By Author)

Favourable Effects	Unfavourable Effects
Better problem solutions, greater productivity, less group think & enhanced decision making (Pelled and Adler, 1994)	Decreased performance, higher turnover and withdrawal (Pelled and Adler, 1994).
Greater communication cross-functionally and cross-boundaries and a more innovative image with management (Ancona and Caldwell, 1992).	Difficulties establishing shared purpose and group cohesiveness, worse performance, less ease with teamwork and openness to political and goal conflicts (Ancona and Caldwell, 1992).
Task-based conflict (Pelled and Adler, 1994).	Emotional based conflict (Pelled and Adler, 1994).
If disharmonies result for group, it may enhance group task-orientation (Brown <i>et al.</i> , 1990)	Communication disharmonies (Souder, 1988).

### 2.5.4. Hypothesis

This review displays the complexity of interrelated team processes and their influence on team effectiveness. This underlines potential difficulties in achieving effectiveness for all teams, including multi-functional teams. Reference to group theories and team research reveals the complexity of group dynamics and the numerous factors which influence team



processes, effectiveness and outcomes. It is therefore difficult to achieve team effectiveness since group processes are influenced by several interrelated factors which have complex impacts on effectiveness and it is unlikely that a team approach will represent an absolute panacea for management problems in innovation.

The review suggests that many characteristics of teams have differential impacts on processes and outcomes; this applies to multi-functional teams which have a membership characterised by functional diversity, known to have mixed positive and negative impacts. These differential impacts suggest that multi-functional team approaches may not be more effective than other team approaches.

Furthermore, the review emphasises the importance of team effectiveness which moderates the impact of teams on project outcomes. Team approaches are not always advantageous for innovation management. Awareness of the advantages and limitations of different types of teams both informs management choice and points to areas where intervention or team building is appropriate.

<b>Hypothesis 4.</b> Multi-functional team approaches may not be more effective than other team approaches.
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## ***2.6. Importance Of Team Approaches For Innovation Success***

Research on the conditions for successful innovation recognises that international competitiveness is affected by productivity growth which is arguably inextricably intertwined with technological innovation (Acs and Audretsch, 1991). The search for the conditions underlying innovation success is fired by high estimates of the failure rate of new industrial products (Kortge and Okonkwo, 1989). However, despite 30 years of research there is no precise prescription for successful innovation (Rothwell, 1992). At times, countries or organisations have been held up as exemplary models of successful innovators. However, the competitive challenge is a dynamic one and no organisation or country can be held up as a successful paradigm (Souder and Sherman, 1994), since today's success may be tomorrow's failure. The implications of the fading excellence of many of the 'excellent' companies such as IBM identified by Peters and Waterman (Peters and Waterman, 1989) and the declining economic strength of Japan, held to be a model of management and economic success, cannot be ignored.

The literature supports a confusing multitude of key factors and studies may not be easily comparable due to differences in the way dependent variables are operationalised and statistics are used (Schewe, 1994). However, it is generally recognised that success is

multi-factored (Rothwell, 1992). These factors can be reasonably generalised in all industries, although some factors gain greater or lesser importance for some sectors (Rothwell, 1992). A review of research on the conditions for innovation success suggests that there are at least four classes of conditions influencing innovation success which include marketing, organisational, project management, and human resource conditions (Table 2.9).

Table 2.9. Conditions For Innovation Success

(Developed by Author)

Companies which innovate successfully fulfil many of the following conditions:
<b>Market-related factors</b> An early marketing orientation (Twiss, 1992, Rothwell, 1992; Freeman, 1986; Caird, 1992) with operations driven by customer not company (Kortge And Okonkwo, 1989) including customer linkages where appropriate (Rothwell, 1992) Attunement to market, especially the intensity of market need, market growth rate, market size, (Rothwell, 1992) and market uncertainties when markets need establishing (Caird, 1992) Convergency between product development process, market and mission (Kortge And Okonkwo, 1989) Attentiveness to potential markets and need to educate and assist users (Twiss 1992) and overcome consumer resistance to innovative products (Caird, 1992)
<b>Organisational factors</b> Relevance to the organisation's corporate objectives and long-term strategy (Twiss, 1992; Rothwell, 1992) Top and general management support and organisational receptiveness to innovation (Twiss, 1992; Rothwell, 1992; Saleh And Wang, 1993) and an absence of organisational constraints (Kortge And Okonkwo, 1989) with long-term commitment to major projects rather than a cash-flow perspective (Rothwell, 1992) Corporate innovation experience (Schewe, 1994), with strong in-house R&D (Twiss, 1992) a source of creative ideas (Twiss, 1992) a receptivity to new ideas (Rothwell, 1992) and a systematic process for screening and developing new industrial ideas (Kortge And Okonkwo, 1989; Twiss, 1992) Risk-accepting culture where innovation is a corporate task requiring flexible responses to technological/market changes (Rothwell, 1992; Saleh And Wang 1993) Capability to finance heavy R&D expenditure (Twiss, 1992) Large-scale production orientation (Twiss, 1992; Schewe, 1994) which is low cost (Twiss, 1992) Achievement of technical development and production synergies between new products and existing products (Rothwell, 1992) with low conflict between the requirements of new projects and existing business (Caird, 1992) Recognition of importance of internal and external communication (Rothwell, 1992) with scientists and customers (Twiss 1992) and a close connection with basic research
<b>Project management factors</b> Effective project management and control (Twiss, 1992; Rothwell 1992) and effective quality control procedures (Rothwell, 1992) Appropriate management for projects of varying levels of project innovation and at different phases of the innovation process with decoupling of innovative aspects from routine aspects of project development and more formal management of the latter phase (Johne, 1985; Jelinek and Schoonhoven, 1990; Rothwell 1992) Effective inter-functional integration (Hayes <i>et al.</i> , 1988; Rothwell, 1992) and co-ordination of R&D, production and marketing (Twiss, 1992) Importance of transfer efficiency from development stage to marketing (Schewe, 1994) assisted by overlapping the problem-solving work of upstream and down-stream groups (Hayes <i>et al</i> , 1988) Shorter lead-times than competitors (Yeaple, 1992; Twiss, 1992), although development time pressures should not lead to hurried market launches (Kortge and Okonkwo, 1989)



Table 2.9. *Continued*

<b>Project management factors</b> Appropriate resourcing and financial backing (Caird, 1992) and resource efficiency (Yeaple, 1992) Technically viable project (Caird, 1992) which benefits the user (Langrish <i>et al.</i> , 1972; Cooper, 1983; Caird, 1992) with the provision of good technical services (Rothwell, 1992) Product uniqueness (Cooper, 1983) although more technologically complex projects are more likely to fail unless market demand is strong (Schewe, 1994) Protection through patents (Twiss 1992; Caird, 1992)
<b>Human resource variables</b> Skilled human resources (Peters and Waterman, 1989; Hayes <i>et al.</i> , 1988; Caird, 1992) with few recruitment or retention problems (Caird, 1992) and a dynamic management commitment to the development of human capital (Rothwell, 1992) <u>Effective key roles in innovation process including</u> - the innovator's role (Madique, 1988; Caird, 1994b) - technological gatekeeper's role in information retrieval and dissemination (Rothwell, 1992) - the project champion's commitment (Twiss, 1992; Rothwell, 1992) - leadership requirements as identified in Section 2.5.2.2. A multi-functional team approach which is appropriate to innovative companies (Maccoby, 1988; Saleh and Wang 1993); benefiting inventivity (Hull and Azumi, 1989) sales and profits (Takeuchi and Nonaka, 1986; Hull, 1990) time-to-market, break-even-time, break-even-after-release and return-on investment (House and Price, 1991); time-to-market, cost-effectiveness and competitiveness (Clarke & Fujimoto, 1991; Yeaple, 1992), commercial success (Shiner, 1992) although it may vary in appropriateness to projects of different levels of innovation and at different phases in the innovation process (See Sections 2.2.5 & 2.3.2).

Research findings on innovation success show that although team approaches may benefit commercial success, other factors are clearly important. However, in considering team effectiveness and innovation outcomes, it is striking that similar broad classes of variables influence both sets of outcomes:

- team membership and interaction variables correspond with the human resource variables important for innovation success;
- team task variables correspond with the project management variables important for innovation success;
- team external environment variables correspond with the organisation and market-related variables important for innovation success (Table 2.9).

The role of the team in the context of innovation success factors may be broadly modelled as follows:

Figure 2.2 Basic Model of Team Influence on Innovation Outcomes

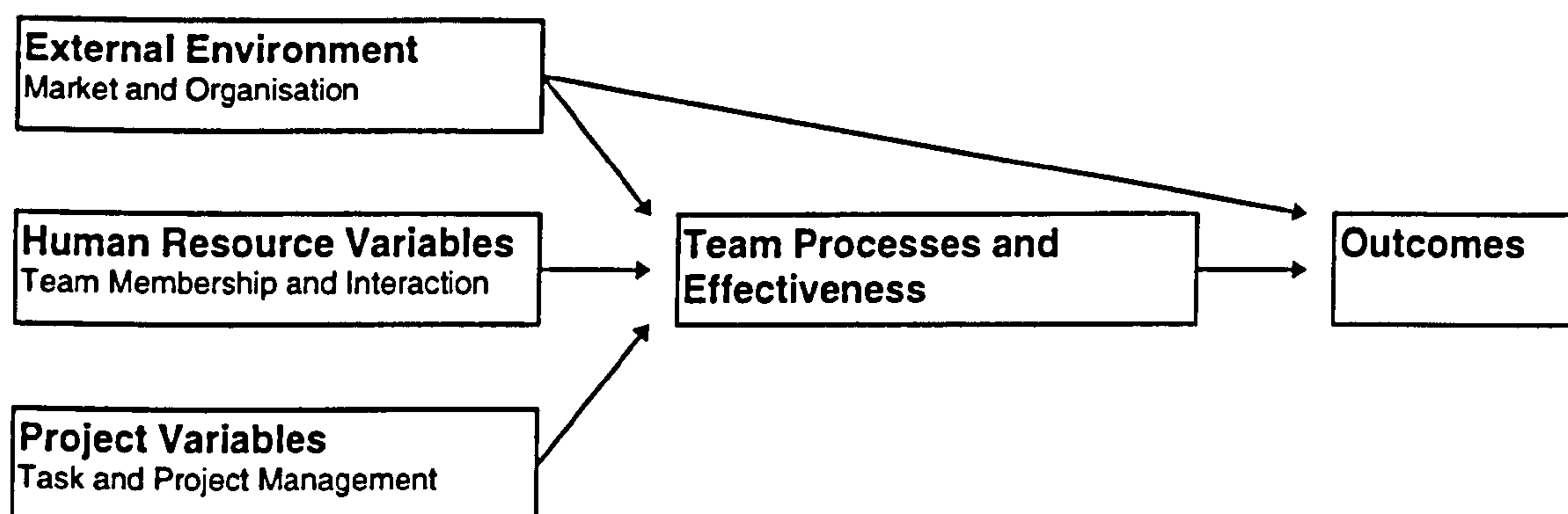


Figure 2.2 indicates the influences on team processes and effectiveness which, together with ‘external environment’ variables, impact on project success outcomes. It has not been determined conclusively which, if any, of the conditions for the commercial success of organisational innovations are most important. One study of 30 randomly-selected industrial product companies found that approaches to innovation could be understood in terms of the time given to the project by different functional groups (Cooper, 1983). The most successful approach had an activity time breakdown as follows: marketing 31.3%, technical/production 55% and evaluation 13.7% (*ibid.*, 1983). This differed to the least successful approach which was dominated by design, with an activity time breakdown as follows: marketing 28.3% technical/production 71.7% and evaluation 0% (*ibid.*, 1983). The low emphasis on evaluation by less successful approaches may indicate poor organisational learning. This study underlines the importance of a management approach optimised to address several conditions for innovation success.

The conditions for success have been classified in several different ways in order to identify the most important conditions. One classification is according to whether factors are firm-related or related to project execution (Rothwell, 1992; Schewe, 1994). Schewe argues by analysing 88 innovative projects that success and its variance can be largely explained by firm-related variables and that project-related variables require less emphasis in the exploration of the conditions for innovation success (Schewe, 1994).

By contrast, Thamhain further classifies the conditions for innovation success according to whether they are people-related, organisation-related or task-related variables (Thamhain, 1990). Thamhain’s study of new product managers of teams in 52 high-technology



companies suggested that task-related variables <sup>4</sup> were more important than people-related variables <sup>5</sup> which were more important than organisational variables <sup>6</sup> for commercial success. Schewe afforded firm-related variables the greatest importance which Thamhain found to be least important. By contrast, Thamhain afforded task-related variables the greatest importance which Schewe found to be less important for innovation success. Another view is that success depends more on individuals than formal management techniques (Rothwell, 1992). Individuals still stand out in histories of innovations where success is due more to the drive and commitment shown by product champions than the scientific and technological creativity of their ideas (Langrish *et al.*, 1972). Hayes supports this emphasis:

‘Superior performance is ultimately based on the people in an organisation. The right management principles, systems and procedures play an essential role, but the capabilities that create a competitive advantage come from people - their skill, discipline, motivation, ability to solve problems and capacity for learning’ (Hayes *et al.*, 1988, p.242).

However, comparisons are not easy to make between studies which respectively rate the superior importance of people (Langrish *et al.*, 1972; Hayes *et al.*, 1988; Rothwell, 1992), firm (Schewe, 1994) or task variables (Thamhain, 1990). Indeed it may not be easy to separate task, people and firm variables in anything but an arbitrary manner, since all are interrelated. Furthermore, it is not clear where market factors feature in such studies which attempt to evaluate the differential significance of innovation success factors.

Another difficulty refers to the way success factors are grouped. Although Schewe regards firm-related variables as most important, the findings emphasise the importance of one firm-related variable which could be regarded as project-related, that is the efficiency with which the product is transferred from the development to the marketing function (Schewe, 1994). Furthermore, Thamhain’s study lists leadership and the experience and competency of team members as task-related variables (Thamhain, 1990) when they could be regarded

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<sup>4</sup> Task-related variables include clear objectives, direction, plans, autonomy, professional challenge, project visibility, leadership and the experience and competency of team members (Thamhain, 1990).

<sup>5</sup> People-related variables include work satisfaction, team spirit, trust, good communication, conflict, power struggles and job security (Thamhain, 1990).

<sup>6</sup> Organisational variables include organisational stability, job security, management support, rewards and resources (Thamhain, 1990).

equally as people-related variables. These discrepancies in classification point to difficulties in interpreting the results of these studies as indicative of superior conditions for innovation success.

The team is one of many factors which influences the commercial success of innovation. Furthermore, the team's impact on success is moderated by both the type of team approach adopted and the team's effectiveness and requires further exploration. Although innovation success is attributable to many causes, the effective multi-functional team approach is likely to be part of the profile of companies developing successful innovative products and processes.

### **2.6.1. Hypothesis**

<p><b>Hypothesis 5.</b> Although innovation success is attributable to many causes, the effective multi-functional team approach is likely to be part of the profile of companies developing successful innovative products and processes.</p>
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# Chapter 3 The Environment Industry And Markets For Technological Innovation

## *3.1. Introduction*

This chapter looks at the nature of the growing environment industry which was the focus for this research project on organisational team approaches to the development of innovative products and processes. This industry was chosen as the research focus for several reasons.

**First**, it is a changing, growing industry about which more information is required, since existing sources about environment markets and sectors are not entirely coherent. Concern has been expressed with Britain's competitiveness in the growing EU and international markets for environmental technological products (See OECD, 1992; CEST, 1991; ENDS, 1992a). Section 3.2. discusses the nature and potential of this industry while Section 3.3. carries these ideas forward to consider the UK scene. Of particular interest in the UK context are issues associated with the enforcement of mainly EU environmental regulations which are influenced by global environmental concerns and 'green' pressure groups. Of interest too is the new commercial power of both the privatised water supply companies and the new ex-government funded environmental agencies. This Section provides a background to this research by considering the opportunities and challenges for companies operating in environment markets.

**Second**, the researcher expected that there would be a presence of innovative small, medium and large-sized firms since the environment industry is growing and changing. As Chapters 2 explains, firm size and level of project innovation may be important influences on team approaches and therefore this is central to the present research. There is evidence that this industry is represented by firms of different sizes. The OECD pointed out that the environment industry has a dual structure, involving both small companies which represent 50% of the companies operating in OECD countries and larger companies which produce 50% of the industry's output (OECD, 1992). Furthermore, Section 3.4. explores the requirement for innovation in the environment industry which has to increasingly address issues of pollution prevention and control.

### ***3.2. The Nature And Structure Of The Industry***

It is difficult to assess estimates of the value of the environment industry, since some estimates are based on a limited definition of the environment industry which has been traditionally limited to particular sectors, such as pollution control and environmental services. In this study the OECD definition of the environment industry is accepted ‘...as including firms which produce pollution abatement equipment and a range of goods and services for environmental protection and management’ (OECD, 1992, p.5).

The environment industry includes environmental services, water and effluent treatment, waste management, air quality control, land remediation and noise control. With this definition in mind, the OECD estimate that the environment industry is worth 200 billion US dollars and will grow by 5.5% per annum to 300 billion US dollars in the year 2000. The OECD claim that the potential of this sector is comparable to the aerospace and chemical industries (OECD, 1992).

Most of the statistical estimates for expenditure in the environmental area are for pollution control and environmental services, although increasingly pollution prevention technological products command a share of this expenditure. However, there are less statistics available on pollution prevention products. The OECD predict that the world market for pollution control equipment could be as much as 50 billion US dollars a year (OECD, 1992). In considering environmental consultancy services, the ENDS directory shows that, within the UK, clients are currently spending 400 million sterling pounds on services annually in the UK (ENDS, 1992b). With 339 environmental consultancies active in the UK, ENDS predicts that market growth will slow, from a rate of 200% over the last 5 years, to a rate of 130%, over next 5 years (ENDS, 1992b). Both the OECD and ENDS emphasise that the markets are growing.

Unlike the OECD and ENDS reports discussed above, the Centre for Exploitation of Science and Technology (CEST) include companies producing pollution prevention technologies in their estimation of the market value for environmental technological products and services (CEST, 1991). In terms of expenditures on environmental products and services, CEST estimate that between the years 1990-2000, 860 billion pounds sterling could be spent in Europe and 1,060 billion pounds sterling in the US (CEST, 1991). The UK alone is estimated to spend 140 billion pounds sterling between 1990-2000 (CEST, 1991). CEST’s estimate for expenditure on environmental products and services is greater



than the OECD's estimate for UK expenditure which is that the UK spent 7 billion US dollars in 1990, but by the year 2000 at a growth rate of 6.3% per annum the UK will spend 11 billion US dollars (OECD, 1992). Even allowing for the vicissitudes of currency exchange fluctuations, CEST present a substantially greater estimate of market growth potential. These differences probably can be explained by different perspectives on the environment industry, where CEST, unlike the OECD, includes companies which are manufacturing pollution prevention products.

The OECD report has criticised the poor availability of statistics which interferes with the estimation of market values, growth, production, trade and market trends and the formulation of policy (OECD, 1992). This is attributable to the relative newness of the industry, although some markets are already relatively mature, such as water and effluent treatment. (OECD, 1992). The industry has fragmented markets and many environmental products and services are currently subsumed under a variety of sectors, including industrial machinery, electrical engineering, chemicals and services sectors. CEST is also critical of the limited focus of most reports on the environment industry (CEST, 1991). However, the OECD suggest that the environment industry could be designated a strategic sector, because not only is it a high growth area, but it has implications for the efficiency and sustainability of other sectors, particularly manufacturing industry which needs to become less polluting (OECD, 1992). Environmental technological products are associated with greater energy efficiency, lower waste, a better use of natural resources and fewer costs associated with litigation and prosecution, all of which are important for the prosperity of industry.

Despite the limitations of existing portrayals of the industry, it is clear that there is a high number of small companies, a strong characteristic of a young industry. The OECD found that 50% of the industry is made up of small companies with less than 50 employees; there are 30,000 small firms in North America, 20,000 in Europe and 9,000 in Japan (OECD, 1992). In the UK context, a report on the 'Environment and Pollution Control Industry' by Inter-Company Comparisons (ICC), estimates that there are 281 registered companies operating in the Environment and Pollution Control Industry; there are 136 small companies with less than 50 employees, 83 medium-sized companies with 50<250 employees and 62 large companies with greater than 250 employees (ICC, 1992). Furthermore, ENDS found that by 1992, there were approximately 339 environmental consultancies, which are mainly small companies (ENDS, 1992b). However, larger firms

from the chemicals, engineering and electronics industries are increasingly diversifying into the environment industry and mergers and acquisitions are increasing as opportunities in environment markets are recognised and grasped (OECD, 1992).

There are differing estimates of the growth potential of markets associated with different environmental media. The world market for water and effluent treatment is currently the largest market segment in the environment industry and will be worth 83 billion dollars by the year 2000 (OECD, 1992). In the UK, ENDS claim that the boom for environmental consultancies is in areas such as water, contaminated land, waste management and air pollution in respective importance (ENDS, 1992b). A slightly different perspective is given for the EU, by the West German State Bank which suggests that the market size is biggest for waste management, then water, energy, air, and soil respectively (Przybilski, 1990). Furthermore, the OECD predict that the world markets for waste management and land reclamation will grow stronger than waste-water treatment and air pollution control markets (OECD, 1992). While in the medium-term, the market for water and effluent treatment is likely to remain the largest environmental sector, it is likely to be outgrown by environmental services (OECD, 1992), which address the environmental management problems of industry.

The main purchasers of environmental products and services, according to the OECD, include municipalities, power and water utilities, mining and traditional manufacturing sectors. The investment expenditure for pollution control is estimated at 2-4% of total manufacturing investment (OECD, 1992). Apart from sectors concerned with environmental management, the sectors which are high purchasers of environmental products and services include the iron and steel industry in Europe, the pulp and paper industry in Japan, and oil refining in the US. Other sectors which invest heavily in pollution control are the chemical and textiles industry (OECD, 1992).

There are different views on which countries constitute the most important markets. According to the OECD, the largest national market is the US market with approximately 40% of the world market (OECD, 1992). However, the West German State Bank, suggest that the EU is the most important market for environmental technological products (Przybilski, 1990). At present, the European market is estimated at 54\$ billion dollars with Germany accounting for over 30% of this market (OECD, 1992). However, the OECD predict that the markets in countries which have adopted less stringent environmental protection legislation will grow faster as they come in line with the strongly regulated



countries which have more advanced, maturing markets (OECD, 1992). Further growth markets are in the richer Asian countries, such as South Korea, Taiwan, Hong Kong and Singapore, where public concern about the environment is rising.

The world market leaders in the environment industry include firms in Germany, Denmark and the Netherlands. At present, Germany, Japan and the US are the largest exporters of environmental products and services. Germany exports 40% of production and only imports 5% (OECD, 1992). This is a very strong position, in view of expectations that the environment industry will show phenomenal growth. The OECD suggest it should be regarded as a strategic industry for both economic and ecological reasons.

'...it is a sector whose technology and products are important to improving performance in many industries, enhancing national trade balances and preserving the world's environment. ...Countries which lag behind in developing environmental products and services may find themselves with substantial trade deficits in this area or a lower quality of environment', (OECD, 1992, p.29).

### ***3.3. The UK And EU Context***

The UK has been criticised for lagging behind and failing to grasp the emerging opportunities in this sector (ENDS, 1992a). The UK exports 14-20% of production, but import penetration is rising faster than exports at 14-15% (OECD, 1992). The British failure to exploit growing opportunities is exemplified by the fall in Britain's exports of water effluent treatment plant from a top position in the EU equipment export league in 1981, to a situation where Britain has become the second largest EU importer by 1989 (ENDS, 1992a). How this happened is unclear, since the UK is in the top three OECD countries, with Germany and the US, for expenditure in the environmental area in absolute terms, spending 170 million dollars per annum which is 2.3% of total government expenditure (OECD, 1992).

Rising imports may be explained by environment legislative requirements for environmental protection. However, this is probably not the whole story because the UK has been criticised for not being supportive of the environment industry (ENDS, 1992a) which is crucially dependant for competitiveness on the enforcement of legislation for environmental protection. Furthermore, the UK's highest expenditure is for the management of environmental media and not environmental remediation and protection (OECD, 1992). However, in the UK, delays in the enforcement of environmental

legislation and regulation have slowed the growth of the UK market which undermines export marketing dependant on a healthy home market. Without the enforcement of legislation, there is little support for companies interested in developing innovative products and processes for environmental protection and pollution control. Despite the Water Act in 1989 and the Environmental Protection Act in 1990, ENDS claim that a decade is lost by the UK in this important industry (ENDS, 1992a).

Furthermore, the UK is not strong on other important competitive factors in the environment industry, such as basic research, the capability to integrate technologies into productive systems, the ability to market globally, price competitiveness and the availability of venture capital (OECD, 1992). Unlike the UK, Japan excels in global marketing and price competitiveness and the US is a good provider of venture capital.

The growth of industrial activity in the areas of environmental protection and pollution control are strongly related to legislative changes in the area. Historically, prior to the 1980's, the environment industry was primarily concerned with the management of water supply and sanitation. The years between 1868-1950 proved to be a formative period for legislation in water quality areas, although problems were identified but inadequately controlled through the enforcement of legislation (Hallett *et al.*, 1991).

From 1973 onwards, the changing concerns of the environment industry towards environmental protection and remediation were related to new European Directives and UK environmental protection legislation. This is reflected in the Control of Pollution Act 1979 which attempts to monitor and control pollution. The emphasis on pollution control did not however play a significant role until 1989, with the Water Act and the Water Resources Act 1991 which require the establishment of a system for classifying water quality. The National Rivers Authority (NRA) was established <sup>1</sup> to demand compliance from industry with water quality objectives.

Prior to the late 1980's it was broadly assumed that nature could cope with anthropogenic sources of pollution. Increasingly, it was realised that the environment did not have the

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<sup>1</sup> The National Rivers Authority (NRA) now replaced by the Environment Agency (EA) was an independent watchdog with prosecution powers. The NRA monitored and controlled water pollution, drainage and river management and was responsible for the management of water resources and the protection of future resources by controlling rates of abstraction. It was also responsible for setting and monitoring national water quality standards in inland, estuarial, coastal waters by providing discharge consents to key polluters in agriculture, industry and sewage treatment.



capacity to absorb the impacts of industrial activity and that environmental problems were accumulating into a lethal legacy for future generations. With the 1990 Environmental Protection Act, pollutants were differentiated, according to the seriousness of their impacts. More polluting substances were completely proscribed, such as mercury and cadmium, whereas companies using less polluting processes were required to implement 'Integrated Pollution Prevention and Control' (IPPC) and protect all environmental media from all negative impacts, using 'Best Available Techniques Not Entailing Excessive Costs' (BATNEEC) and the 'Best Practicable Environmental Option' (BPEO). With this Act companies were required to set up monitoring systems to demonstrate their compliance with the duty of care requirement of this law and ensure the secure transfer and safe disposal of wastes. Furthermore, in the 1990's many companies began to seek a 'greener' image by adhering to standards set for the management of environmental impacts by the voluntary British Standard for industry on environmental management BS7750, (replaced by ISO9000).

However, although there were tighter controls on pollution with the Water Act in 1989, they were not implemented for many years because of the perceived costs for industry (Hallett *et al.*, 1991). The impact of regulation on industry and economic growth was considered to be of greater importance than the negative environmental impacts of industrial activity. This view remains despite the market potential in this area and the perceptions that greater efficiency may occasionally be associated with improved environmental standards. So although in theory UK environmental legislation should create many opportunities, such as for pollution prevention and waste-minimising technologies which have minimal environmental impacts, the extent of these opportunities may be curtailed, in the short-term, by the poor enforcement of legislation. The policing powers of Her Majesty's Inspectorate for Pollution (HMIP) <sup>2</sup> were under-resourced with the result that companies were expected to monitor themselves (CEST, 1991). With the merging of the HMIP, NRA and the Waste Regulation Authorities into the Environment Agency in 1996, it transpired that the Conservative government has moved to undermine powers by deregulating industrial pollution since regulations are a perceived burden on industry (Baum, 1993).

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<sup>2</sup> Her Majesty's Inspectorate of Pollution (HMIP) now replaced by the Environment Agency (EA) policed pollution through random audits.

However, the EU is set to adopt a stronger role in legislating for greater environmental protection in member countries. By 1992, the EU had integrated environmental issues as part of the Single European Act, within sections 130r, 130s, 130t; this promised to preserve, protect and improve environmental quality, to ensure a prudent and rational utilisation of natural resources and to contribute towards the protection of human health. The EU is responsible for environmental legislation, such as Directives on:

- Urban Waste Water which demands improvements in the quality of many sewage discharges and limits industrial effluent;
- Groundwater Protection which pressurises landfill operators to reduce groundwater contamination risks associated with leachate;
- Integrated Pollution Prevention and Control (IPPC) which has been discussed above;
- Ecological Quality of Water which is concerned with the deterioration of EU water quality and aims to control the pollution of surface waters from point sources and non-point sources with diffused pollution.

According to the OECD, the primary driver of the environment industry is the environmental policy and legislation of the OECD country (OECD, 1992). There are clear sectoral and regional variations in environmental policy and legislation and an interesting manifestation of these variations is the correlation with market leadership in specific environmental problem areas: for examples, Japan excels in air pollution control, the US dominates the market for toxic waste management and Germany dominates pollution abatement and water equipment (OECD, 1992). Although the Netherlands and Switzerland are less dominant within the environment industry, they excel respectively in land contamination remediation efforts and specific waste and water pollution control techniques as a result of targeted legislation and public concern (OECD, 1992). The OECD claim that:

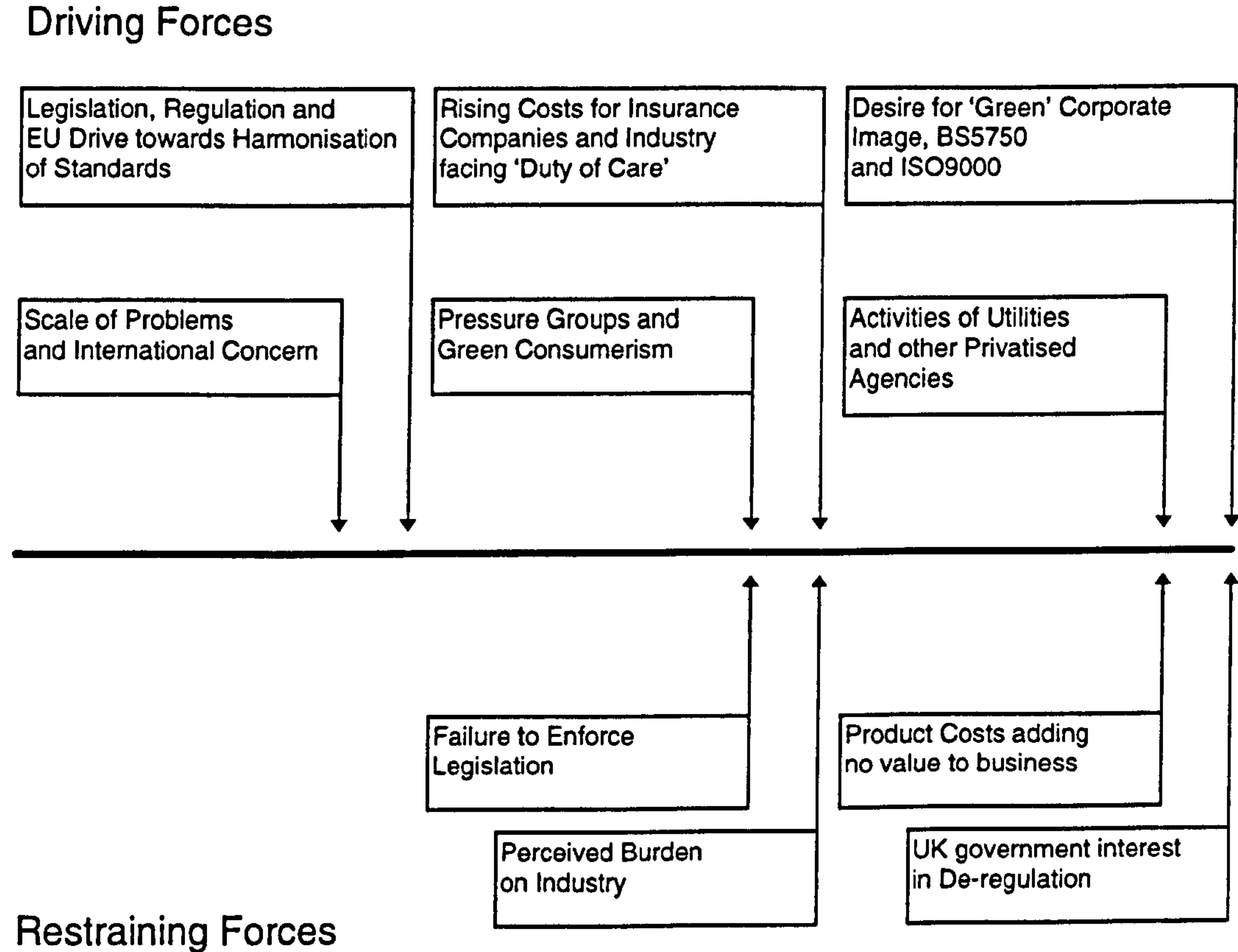
‘The largest most technically advanced environmental markets...have developed in those countries with the most comprehensive and effective environmental regulations’ (OECD, 1992, p.19).

Countries have varied in terms of the environmental legislation established and the stringency of standards adopted. However, there is drive towards the harmonisation of



standards within the EU and a steady trend towards the application of more stringent standards in all product segments and most geographic regions. Although EU negotiations usually represent a compromise between countries with higher and lower environmental standards and there is much leeway granted in the enforcement of legislation, there is nevertheless the tendency for international agreements to get tougher, because of the vested business interests and environmental concerns of countries with higher environmental standards. This may favour countries at the forefront of environmental legislation, such as Germany, Scandinavia, Netherlands, US and Japan, which have the advantages of an established home-base. It is probable that market leaders may press for stricter international standards via industrial pressure groups, in order to maximise their advantage and promote international environmental protection. Legislation and its enforcement has an essential role which will increase as a result of public concern, pressure groups as well as the drive towards the harmonisation of EU standards. Figure 3.1 displays the factors stimulating industrial growth, also acknowledging the factors restraining industrial growth, such as the perceived costs and burden for industry.

Figure 3.1: Influences on the Environment Industry



With the Water Act of 1989, 10 public regional water authorities became privately owned privatised water services companies in England and Wales. In Scotland the Scottish River

Purification Boards and Regional and Island Councils were excluded from this legislation

3. With privatisation, the new water service companies have greater capital at their disposal, which creates a demand for services from many of the new environmental consultancies (ENDS, 1992b). Business opportunities may be generated as water companies plough their profits into improving water quality. On the other hand, the Sunday Times report that the water companies have been convicted of numerous pollution offences for failure to clean up illegal sewage effluent contaminants (Ryan, 1993).

Figure 3.1 also shows that while legislation and regulation promote the industry, the failure to enforce legislation and de-regulation restrains the development of the industry. Although, environmental concerns may prove to be a burden on industry, in terms of additional costs and bureaucracy, the failure of industry to become 'greener' may also have financial repercussions for industry. As pollution legislation becomes tougher, the costs of cleaning up pollution is becoming more expensive than pollution prevention. In the US, firms are liable for clean-up costs related to activities which may have taken place up to forty years ago, for example Ford was compelled to pay 4.3 million dollars to address groundwater pollution at an old production site in New Jersey before being allowed to close down the factory and move on (Elkington, 1980).

Also related are the increasing concerns of insurance companies about environmental liability, with the result that increasingly premiums will be lower for companies which adopt pollution prevention technologies. Such financial concerns are not likely to

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<sup>3</sup> Prior to the Water Act, there were already some private water supply companies which became subject to the same regulations as the new water plc's. The regulators include the following:

the Drinking Water Inspectorate (DWI) which assists the Secretary of State for the Environment and local authorities in ensuring drinking water quality is monitored and maintained;

the Office of Water Services (OFWat), which through the Director General, has the primary responsibilities to ensure that the Water Companies (both supply and service plc's) can carry out the functions of water supply, disposal and to look after the interests of customers by controlling increases in water charges and monitoring services;

the National Rivers Authority (NRA), now replaced by the Environment Agency was an independent watchdog with prosecution powers to monitor and control water pollution, drainage and river management. It was responsible for the management of water resources and the protection of future resources and for setting and monitoring national water quality standards;

Her Majesty's Inspectorate of Pollution (HMIP), now replaced by the Environment Agency, previously policed pollution through random audits; the Department of the Environment (DOE), Local Authorities, the Monopolies and Mergers Commission and the Ministry of Agriculture, Fisheries and Food.



disappear since the rate of real economic growth is smaller than the costs of environmental degradation (See Pearce *et al.*, 1989). Although the unwillingness to burden industry with regulations may prevail in the short-term, according to Pearce, the failure to attribute value to environmental resources in the global sense, amounts to false accounting and the failure to ensure inter-generational and intra-generational equity (*ibid.*, 1989). This suggests the growth of the environment industry may coincide with lower economic growth for industry in general. On the whole, it does appear that ‘...industry can become greener only by growing more slowly’ (Cairncross, 1991, p.143).

For the environment industry, time will tell if the poor enforcement of legislation and the perceived burden on industry should prove to be more restraining than the driving forces of international environmental concerns which are supported by pressure groups, public concern, ‘green’ consumers and countries supporting more stringent standards in environmental protection. The delay in the UK to regulate industry, may reduce the onus on industry to improve environmental standards in the short term, but in the longer term the UK may lag further behind the market leaders within the environment industry. The failure to bolster the home market for UK companies may make it more difficult for smaller companies to survive if they have to export to countries with higher environmental standards. While the environment industry may grow globally, at the possible expense of industrial growth in other industries, the UK industry may not keep pace.

### ***3.4. Opportunities For Environmental Innovation***

Environmental technology encompasses an inter-disciplinary field, including civil and mechanical engineering and the disciplines of hydraulics, hydrology, biology, geology, chemistry, biotechnology, recyclable material research, botany, medicine, chemical process technology and micro-electronics. Environmental technology strives to meet the two objectives of public health protection and environmental resource protection. Environmental technologies often duplicate natural processes within artificial ecosystems by trying to speed up nature’s management of pollution. For example, in water purification the purposes are to remove harmful micro-organisms or chemicals with treatments such as sedimentation, coagulation, filtration, disinfection, aeration, fluoridation and so on. In waste water treatment, the purpose is to destroy pathogenic micro-organisms and remove suspended and biodegradable organic materials and plant nutrients. With sewage treatment, there is a need for staged treatments, including a preliminary stage of screening and sedimentation, a secondary stage, involving biological treatment to remove suspended

solids and dissolved Biological Oxygen Demand (BOD), followed by a tertiary stage where plant nutrients are removed. According to Nathanson:

‘Environmental technology involves the application of engineering principles to the planning, design, construction and operation of systems for: drinking water treatment and distribution; sewage disposal and water pollution control; stormwater drainage and control; solid and hazardous waste disposal; air and noise pollution; general community sanitation’ (Nathanson, 1986, p.1).

Pollution refers to the harmful contamination of the environment, with particular reference to human values for human, animal or plant life (*ibid.*, 1986). Sources of pollution may be more broadly grouped into the categories of anthropogenic, industrial and natural sources of pollution. Key sources of pollution include pathogenic organisms, oxygen-demanding substances, plant nutrients, toxic organics, inorganic chemicals, sediment and soil erosion, radioactive substances, heat and oil spills (Nathanson, 1986). The problems posed by pollution for which technological solutions might be sought include the following:

1. Pollution can accumulate, e.g. radio-active waste in the Irish Sea.
2. Pollution can have long-term effects, e.g. the purification of chemically contaminated groundwater could take centuries.
3. Pollution can have a long-range effect, e.g. the gas emissions, sulphur dioxide and nitrous oxide from fossil fuel burning can cause acid rain which affects rivers, lakes, forests and soil.
4. Pollution may have a fundamental effect, e.g. the impact of CFC's and fossil fuel burning on global warming.
5. Pollution may create incidental effects on all environmental media, e.g. the penetration of leachate through landfill sites contaminates land, surface water and groundwater resources.
6. Pollution in low levels of concentration may be difficult to detect, e.g. pesticides in soil where pollutants may scarcely affect taste or odour.
7. Pollution may accumulate in the food chain, e.g. mercury.



8. Pollution may disperse, as with non-point source pollutants which have the ability to disperse over wide areas of the aquifer making it difficult to clean up contaminated groundwater.
9. Pollution may have economic repercussions, such as the difficulties and costs of clean-up.
10. Pollution may impact on future generations and less-developed countries which are often treated as hazardous waste dumps, therefore leading to inequity and the political repercussions of inequity.
11. Pollution impacts are relative to some extent, for example with water pollution almost any substance can become a pollutant if present above a critical level (Charter, 1990). The Water Resources Act 1991 requires the NRA to establish a system for classifying water quality through regulations, but since water pollutants are always relative to intended usage, the NRA established use classes as a basis for water quality objectives in 1992 <sup>4</sup>.

Technological opportunities include addressing the above list of pollution impacts. According to CEST, the areas of greatest potential include the reduction of greenhouse gas emissions, water quality and waste management, although issues rising on the environmental agenda include electromagnetic radiation, water quantity, the future of cars and the quality of groundwater (CEST, 1991). Furthermore, there are opportunities for the development of new techniques required by legislation and regulations, such as IPPC, BATNEEC, BPEO and waste disposal regulations (CEST, 1991). Furthermore, there are always opportunities for the reduction of costs associated with environmental technologies which may be important in view of government perception of the burden posed by environmental regulations. Another area of opportunity is with the development of non-intrusive technologies which have no negative environmental impacts (*ibid.*, 1991).

According to CEST, it is generally accepted that much of the pollution control technology already exists, despite substantial R&D in this area (CEST, 1991). This would suggest that

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<sup>4</sup> These classes of use include the fisheries ecosystem, abstraction for drinking water supply, agricultural abstractions, industrial abstraction and special ecosystems needs, such as sites of special scientific interest and water sports. Outside this statutory scheme the government also proposes the development of a general quality assessment which will incorporate biological, chemical, nutrient and aesthetic assessments (CBI, 1993).

emerging innovation in this area would be minor rather than radical. Others claim that there is a need for a new generation of technologies characterised by energy and resource efficiency (Przybilski, 1990; Cairncross, 1991). According to CEST, market opportunities for environmental technological products include:

1. Monitoring technologies which have 3 constituents: (a) measurement of parameters by on-line sensors (b) signal processing and (c) presentation of data.
2. Remediation and Abatement technologies including 'end-of-pipe' and add-on pollution control equipment.
3. Recycling technologies which are concerned with reorganising process and supply chains in order to reduce unwanted by-products.
4. Clean, low-waste technologies and the installation of processes which are designed to minimise negative impacts.
5. Systemic technology changes to industrial processes, pertaining to the restructuring of the whole organisation. This is most required in highly polluting industries, such as energy supply, transport, chemical industry, water supply and agriculture (CEST, 1991).

The market opportunities may be less for 'end-of-pipe' remediation and recycling technologies which are mainly driven by regulations unlike the clean and systemic technologies which may yield financial and competitive gains (OECD, 1992). Both OECD and CEST are in agreement over the shift of market opportunities away from the producers of 'end-of-pipe' solutions towards the process plant manufacturers, who develop cleaner technological products and environmental solutions which are integrated with the whole manufacturing operation. The trend is significant because it would lead to some competition between pollution control versus pollution prevention equipment and waste transformation versus waste reduction technologies.

### **3.5. Conclusions**

Of course the view that technology has the answer to environmental problems is questionable and Cairncross questions the view that the best hope for the environment lies in accepting the 'paradox of technological development', which is that technological cycles lead to damage and repair which create new problems, new technologies and new side effects (Cairncross, 1991, p.148). Accepting such logic, technological solutions are being



sought for environmental problems and the environment industry is predicted to show phenomenal growth. The poor availability of statistics describing the environment industry and the scarcity of scientific information on environmental problems interferes with the estimation of market values, market trends, growth areas and the formulation of policies. Furthermore, it is difficult to estimate precisely the value of the market, since the structure of the industry is changing with greater demand for 'cleaner' pollution preventing technologies, which are likely to be produced by sectors not currently described within the context of the Environment And Pollution Control Industry (ICC, 1992). However, the OECD have designated the environment industry a strategic sector.

The primary driver for the industry at present is the growing body of environmental legislation. The enforcement of this legislation activates other important forces, such as insurance companies and financial institutions which stand to lose from claims for environmental damage. The UK is presently lagging behind the market leaders within this industry which include Germany, US, Japan and the Scandinavian countries. This is because of an unwillingness to burden industry with the bureaucracy and technological requirements associated with regulation leading to delays and the failure to enforce environmental legislation with adequate policing. The result may undermine British industry in the longer term. Britain is already a poor follower in a growing industry and it is likely that EU moves to harmonise environmental standards within its member states will increase Britain's pace of importing environmental goods.

In addition to suggesting that the environment industry is growing, Chapter 3 shows that innovative technological developments are required to address environmental problems, although minor innovation may be appropriate since the required technology may already exist. The dependency of companies operating in these markets on the enforcement of legislation in a climate of government reluctance to burden industry with regulation suggests potential difficulty for companies trying to innovate in these markets and small companies which are recognised as 'fragile' (Slatter, 1992) may be particularly vulnerable in the UK context.

# Chapter 4 Research Methodology

## ***4.1. Introduction***

This chapter outlines both the research methodology and the logic underlying the research design by specifying the linkages between research questions and hypotheses, investigation methods and the approach to analysis which leads to the findings outlined in Chapters 5-9.

## ***4.2. Hypotheses***

The multiple case study, of team approaches adopted by organisations, explores the appropriateness of multi-functional teams to companies of different sizes working on development projects, of varying levels of innovation, for different markets. The case study explores the importance of team approaches and their effectiveness for the success of innovative products and processes. The research is exploratory in focus which is justified since there is a poverty of formal research on organisational teams and most studies on groups have been carried out in laboratories (Ancona and Caldwell, 1987). What follows is an outline of the theoretical hypotheses which have been derived from the literature review in Chapter 2. In some cases when there are rival theories, hypotheses are expressed in an open ended manner.

The literature suggests that the integration of staff representing different functional backgrounds is essential for the development of innovative products and processes, although different organisational structures, including teams may be adopted as a co-ordination mechanism for innovation management.

Hypotheses 1 The management of innovation is associated with different organisational team approaches which are differentiated by the extent of the integration of departments, the diversity of staff backgrounds and the extent of integration during the development process.

The literature suggests that there are several influences on the appropriateness of team approaches to innovation. The different approaches adopted in companies with the development of innovative products and processes are primarily influenced by the level of project innovation, firm size, organisational structure, the companies involved and the nature of the markets. These factors probably account for differences in the nature and operations of organisational teams in companies. Although the influence of all these



factors are considered in the analysis of the research findings, the research has been designed to explore the influences of the level of technological innovation and firm size on the team approach adopted in innovation management.

Hypotheses 2: Although teams are appropriate to projects of varying levels of technological innovation, more innovative projects are associated with integrated team approaches.

Hypotheses 3: Multi-functional teams are appropriate to large firms involved with innovation developments. It is likely that small firms will informally adopt multi-functional teams. The appropriateness of multi-functional teams to medium-sized as well as inter-company collaborative projects requires exploration.

Hypothesis 4: Multi-functional team approaches may not be more effective than other team approaches.

Hypothesis 5: Although innovation success is attributable to many causes, the effective multi-functional team approach is likely to be part of the profile of companies developing successful innovative products and processes.

### ***4.3. Rationale For Case Study Approach***

Chapter 1 has described the case study as ‘An empirical inquiry that investigates a contemporary phenomena within its real life context, when the boundaries between phenomena and context are not clearly evident...’(Yin, 1984, p.23).

The main reasons for adopting a case study approach that employs both interview and questionnaire techniques for investigation include the following:

- an interest in investigating organisational team approaches to innovation, an under-researched area;
- the presence of too many variables to justify the sole use of methods, such as questionnaires and surveys on a large sample;
- an interest in concepts such as multi-functional teams which are not widely understood or perhaps used by managers in the innovation field;

- the requirement for an in-depth approach to explore complex variables in diverse organisational contexts, where diversity and complexity are of greater interest than simple generalisations;
- the confidential nature of the information sought on the importance of teams;
- an interest in diversity, randomness and experimentally uncontrollable environments;
- an interest in causation and explanation rather than the incidence with which a phenomenon takes place;
- an interest in building theory by generalising from particular cases to the level of theory.

Several cases were chosen in a multiple case study for a number of reasons.

**First**, the variation in companies clearly indicates that no two companies were identical and therefore one company could never provide sufficient evidence to support a theoretical proposition.

**Second**, according to Yin, more cases are needed when the external conditions are more complex and this is true of business organisations (Yin, 1989). The intention was that the selection of 25 companies involved with 28 projects for study would lead to a greater understanding of the range of organisational team approaches adopted in innovation developments and the complexity of their management and team processes.

**Third**, according to Yin 'If two or more cases are shown to support the same theory then replication may be claimed'; this is called literal replication (Yin, 1989, p.38). Theoretical replication is demonstrated when a rival theory is denounced. With case studies, replication logic treats every case as a mini experiment which supports, refutes or enlightens a theoretical proposition. The investigation of multiple company cases helps to provide validity and replication support for the theoretical propositions and the findings which emerge from the analysis of this research.

#### **4.4. Sample**

This Section provides information on the nature of the teams, projects and companies represented in the sample. In addition the sample selection procedures are described below.

#### 4.4.1. Sample Selection

Initially, the sample selection process focused on small and medium-sized companies (SME's) which developed environmental technological products and processes<sup>1</sup>. It was decided to look at team approaches in large companies as well to provide greater comparative information on team approaches, especially the multi-functional team. Cases were selected to reflect the following key criteria for sample selection. Companies should:

- represent company size differentials and include small-sized (less than 50 employees) medium-sized (50>250 employees) and large-sized companies (greater than 250 employees) (ICC, 1992);
- be involved in the development of innovative products and processes with potential/actual environmental applications;
- be involved with projects which were under development between 1988-1995;
- use team or other management approaches to the development of innovative products and processes with especial interest in team approaches;
- include companies which develop innovative projects, either in-house or within inter-company arrangements;
- reflect the market differentials of different products and processes, such as whether the project is customised and client-funded or standardised for launch onto open markets.

The sample selection process involved the adoption of five approaches.

The first approach required the perusal of databases such as the FAME database and the ICC and ENDS environmental directories and market surveys (ICC, 1992; ENDS, 1992(b)). However, the directories have limited value for the following reasons:

- they provide no information on whether the company is involved with innovation and R&D programmes;

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<sup>1</sup> The diversity of projects encountered indicated that some technological projects had applications in markets other than environmental markets.



- they provide no information on the geographical location of R&D operations which can affect the accessibility of companies for research purposes;
- they exclude companies attempting to diversify into environmental areas.

A **second** approach involved advertising my interest in contacting innovative companies through the magazine for the Water Industries Association in December 1992.

A **third** approach involved directly contacting companies exhibiting at the 1993 and 1994 annual Environmental Technology Exhibition held in Birmingham National Exhibition Centre.

A **fourth** approach involved following up companies identified by the DTI as actively developing environmental products or processes (DTI, 1992).

A **fifth** approach was to follow up referrals which resulted from company interviews or the recommendations of colleagues.

A **sixth** approach to sample selection involved the perusal of innovation award winners of competitions such as SMART <sup>2</sup>, the Environment Award for Engineers <sup>3</sup> and the ETIS Award <sup>4</sup>. Awards appeared to be the best way to select the sample because they clearly indicate if companies are developing innovative products. The co-operation of the Engineering Council helped the author to contact anonymous entrants to the “Environment Award for Engineers” competition with a questionnaire which was primarily designed to identify suitable companies for the present research (See Appendix 1). Since this presented an opportunity to gather preliminary data for the research, the questionnaire also included an inquiry about the problems experienced by engineers which led to a joint publication by the author and other researchers (Caird *et al.*, 1994).

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<sup>2</sup> The Small Firm’s Merit Award for Research and Technology (SMART) award is a Government scheme to support small innovative companies. The SMART award is a regionally co-ordinated competition for innovators across Britain, who are having difficulty in attracting investment for high-technology projects.

<sup>3</sup> ‘The Environment Award for Engineers is a competition organised by the Engineering Council and sponsored by British Gas to support innovation.

<sup>4</sup> The Environmental Technology Innovation Scheme (ETIS) is a discontinued British Government scheme which aimed to support pre-competitive environmental projects.

Companies identified as innovating in areas with potential environmental applications were contacted initially by phone with a follow-up letter to provide further information on the research project (Appendix 2). The intention was to establish whether companies adopted team approaches and were prepared to give a face-to-face interview about their management approach. However, it was not always possible to know in advance of a company visit whether the case would help test the hypotheses because the criteria for case selection were not always possible to fully establish by telephone or letter.

Only one company refused to participate in the research project as a result of business pressures on available time. Company team members were very co-operative; some gave reasons such as an interest in supporting British industry and the development of knowledge for their support of the present research. Furthermore, it was clear that many participants wished to discuss their project work because they considered it exciting and the interview gave them the opportunity to think through their project. Some participants hoped that participation in the research project might provide them with publicity or help them to network with other companies, although most preferred anonymity. The willingness of companies to participate was probably also helped by my own enthusiasm and conviction that the research project was interesting and potentially helpful to project managers and teams associated with technological project developments.

#### **4.4.2. Sample Overview**

Table 4.1. provides an overview of the companies, the projects and the team members who participated in this research project.

Table 4.1. Overview of Sample

Abbreviations:

P = indicates interviewee

S = indicates that it was mainly a single person project

Q indicates questionnaire respondent

X= indicates that the company adopted a team approach

Note Company names have been disguised and information on projects has been limited in order to support the confidentiality of the teams, their projects and companies.

Company	Number of team participants	Company size at the time of the innovative development	Team approach to innovative products/ processes	Type of innovative products/ processes
Datalog (Environment Award for Engineers winner)	4 P	Medium	X	Water quality measuring product
R&D Laboratories	3 P	Small	X	Water quality measuring product
Systems Engineering	1 P	Small Subsidiary	X	Plant to supply clean water
Wasserpur	1 P 3 Q	Medium Subsidiary	X	Water purification product
Gulls Exports ETIS award holder	2 P	Small	S	Plant to incinerate waste
Effluent Treatment Systems	1 P	Medium Subsidiary	S	Sludge waste separation plant
Filtratec (ETIS and SMART award holder ) 2 projects considered	2 P 1 Q	Small	X  X	(1)Water purification plant for cryptosporidia (2)Industrial effluent treatment by advancing membrane technology plant
Pollution Control Engineering (Environment Award for Engineers winner)	2 P 1 Q	Small Subsidiary	X	Gas effluent cleaning treatment plant
New Carbon Ventures (Environment Solution for Industry Award winner)	3 P	Medium Subsidiary		Re-activation of carbon water filters system
Sludge Treatment Systems (Pollution Abatement Technology Award winner)	1 P	Medium	X	Anaerobic sludge digestion treatment plant
Wind Power Projects (Smart award holder)	1 P	Small		Wind powered waste water treatment system
Water Services	1 P 2 Q	Large Subsidiary	X	Water quality monitoring product using particle size analysis



Table 4.1. *Continued*

Cheminstrum (SMART award winner)	1 P 1 Q	Small	X	Product to measure impact of chemicals on environment
Analytik 2 projects considered	1 P 3 Q	Large Subsidiary	X X	(1) Disposable environmental monitoring sensor product (2) Effluent monitoring sensor product
Robinson Engineering	1 P 2 Q	Large Subsidiary	X	Sewage treatment plant
Powerengineering	1 P 2 Q	Large Subsidiary	X	Clean power generation plant using gasification methods
CWT Engineering	1 P 1 Q	Large Subsidiary	X	Effluent treatment plant
Sensorval	1 P	Small	X	Pollution detection in water product
EMS	1 P 1 Q	Large Subsidiary	X	Environmental monitoring station product
Longman Engineering 2 projects considered	1 P	Large Subsidiary	X X	(1) Geographical information system for environmental hazard monitoring (2) Environmental monitoring in specific environmental areas
Engineering Projects	2 P	Large Subsidiary	X	Hazard warning system for personnel safety
Biogentech	1 P	Small Subsidiary	X	Water quality monitoring product
Water Quality Utilities (Environment Award for Engineers winner)	2 P	Large Subsidiary	X	Quality control of drinking water supplies
Greenwater	2 P	Small	X	Buildings waste water re-use system and water conservation project
Innovconsult	4 P	Medium Subsidiary	X	Bio-degradable packaging materials
<b>Total = 25 companies</b>	<b>Total 41 P Total 17 Q Total =58 team members</b>	<b>Total Small=10 Medium =6 Large =9</b>	<b>Total 24 project teams 4 non-team approaches</b>	<b>Total =28 projects</b>

**Note** At times it was difficult to establish company size.

For example, **Sludge Treatment Systems** reduced in size to a small subsidiary on the verge of liquidation from being a medium-sized company. It is listed as a medium-sized company, since that was its size at the time of the innovative project development.

Another example is the case of **Powerengineering**, a large firm which had seconded staff to work in a small independent company which was the focus for the innovative development work. This case was classified as a large firm because the participating team members came from the large company.

Furthermore, company size differentials are obscured by the fact that many companies were involved with collaborative ventures with companies of a different size. Outside considerations of inter-company arrangements, these companies are classified according to the size of the companies employing the interviewee.

#### ***4.5. Methods Of Investigation***

Following the arrangement of interviews in companies, face-to-face interviews were conducted in 25 companies between February 1993 and May 1994. Since the interest was in gaining an in-depth understanding of company approaches to developing technologically innovative products and processes, interviewing was the most appropriate initial research approach. The design of the interview questionnaire was completed by September 1993 (Appendix 2). The interview questionnaire was designed to focus on gathering information which could be used to test hypotheses and theoretical propositions. The interview strongly focused on the innovative project because without a clear understanding of group tasks, it is likely that incorrect generalisations about group behaviour will be made (Ancona and Caldwell, 1987).

In general, the interview questionnaire was used as a guide. The majority of interviewees agreed to be tape-recorded and were willing to discuss their approach to developing innovative products and processes at length. This meant that the main interviewing role was to ensure that important questions were answered and appropriate information gathered.

In the case of 14 projects there was no information on commercial outcomes available at the time of the first interview, since the projects were either incomplete or not commercially launched. Of these projects, 4 involved non-team approaches of various kinds. Since there were too few companies which did not use team approaches to allow for statistical analysis, it was decided not to further investigate these companies. The research focused on in-depth cases of team approaches because investigations were time-

consuming. Ten of these unfinished projects involved team approaches and were expected to be commercially launched, so it was decided to follow up these cases in November 1995 with a telephone interview. The focus of these telephone interviews was to get an update on the project's development in order to gain information on commercial and technical success outcomes, the role of the team and the reasons for the outcomes (Appendix 2).

Following initial interviews it was decided that it would be interesting to explore team perceptions and processes in greater detail in order to substantiate and elaborate on interview findings about company team approaches. This led to the design of a third questionnaire (Appendix 3) which was targeted at team members associated with projects in companies where an interview had taken place. Team members were contacted between April-May 1994. In all cases, the permission and co-operation of the original company team interviewee was sought. In some cases team members were invited to participate by the initial interviewee and in other cases, names were passed on which led to contact by letter (Appendix 3).

The use of company and project background information in addition to interviewing 41 project team members and gathering questionnaire data from a further 17 team members, provided a depth of insight into team approaches and processes. The following methodological issues need to be considered when interpreting the findings:

- some project teams were evaluated retrospectively and others longitudinally;
- in cases of inter-company projects, only one company was interviewed;
- cases differed in terms of the number of people interviewed and the nature of their expertise and functional background; (See Table 4.1.);
- there were often difficulties in getting precise commercial information, although it was easier to obtain management appraisals of commercial outcomes;
- there were differences in the extent to which each interviewee was prepared to discuss the company's approach to developing innovative products and processes which affected the detail of interviewee responses.



## 4.6. Operational Definitions

**Innovation** refers to the commercialisation of technological change (Rothwell, 1992). Although innovation and invention may be distinct activities or outcomes, they are often part of the same process; invention is an original, technical and patentable process with no necessary commercial application, whereas innovation involves the application or combination of technologies to solve problems usually for commercial gain (Caird, 1992). The typical innovative product development process or new technology development process involves idea generation, concept development, market definition, R&D, manufacturing or construction, launch and follow up service, although variations are possible (Souder and Sherman, 1994).

A **team** may be defined as ‘...a small number of people with complementary skills who are committed to a common purpose, performance, goals and approach for which they hold themselves mutually accountable’ (Katzenbach and Smith, 1993, p.45).

Teams may be classified as follows:

- by team characteristics including membership, team interaction, task and external relationships;
- by the location of teams in the organisational structure and the contribution of departments to the team approach;
- according to their effectiveness or their outputs.

The ‘new paradigm’, multi-functional approaches to the management of the development of innovative products and processes which were discussed in Chapter 2 (See Hayes *et al.*, 1988) are both defined by the team membership which is drawn from several departments and by greater effectiveness than more traditional single-disciplinary approaches. Teams associated with traditional approaches are usually located within departments.

Single-disciplinary teams are dominated by a single scientific, engineering or technological disciplinary expertise, but could include administrative staff.

Chapter 2 showed that the aim of multi-functional team approaches, when intentionally set up, is to achieve the following outcomes: to improve inter-functional relationships; to assist the cross-fertilisation of ideas; to reduce design errors; to enhance design quality; to improve market targeting of products and product families; to speed up time-to-market; and to improve profitability and competitiveness. These benefits may be achieved by promoting communication and shared responsibility between the different functional groups of design, production or construction and marketing. For the purposes of this

research, it was necessary to develop a definition of multi-functional teams which was separate from associated effectiveness outcomes and the notion that multi-functional teams represent best practice in the management of innovation developments. In order to allow for the identification and evaluation of multi-functional team approaches, the definition adopted for classification excluded the alleged benefits from the initial definition and focused instead on the type of disciplines and business functions involved with the team, that is team membership characteristics. Furthermore, the definition given below excludes a description of the nature of member integration throughout the innovation development process, since the implementation of the multi-functional team approach is also an issue requiring further investigation.

The multi-functional team includes members with:

- either scientific, engineering or technological expertise;
- business functional expertise, particularly in sales, marketing and production;
- and possible expertise in administration, purchasing or finance.

Team membership may be sourced in-house or involve other companies representing clients, consultants, partners or sub-contractors and so on.

In the course of the research it became clear that not all teams with a multi-disciplinary membership could be classified as multi-functional, due to the absence of staff representing some business functions from the team. Although multi-disciplinary and multi-functional teams are both integrated team approaches, it was decided to distinguish multi-functional teams from multi-disciplinary teams which have also been called cross-disciplinary or inter-disciplinary teams.

The multi-disciplinary team has members who represent more than one scientific, engineering or technological disciplinary expertise. Membership could include expertise in administration, purchasing or finance but excludes other business functional expertise. Team membership may be sourced in-house or involve other companies representing clients, consultants, partners or sub-contractors and so on.

#### **4.7. Analysis Methods**

The approach to case study analysis included both a findings-led and theory-led analysis which involved the following steps:

1. Company reports were written following interviews. These reports were kept confidential to the researcher and supervisors. When requested by companies, reports were sent to the managers interviewed. Although invited to comment, none of the companies involved did so.

2. Later original company reports were augmented when possible both by questionnaire responses from other team members associated with projects under investigation and telephone interview information on success outcomes in projects followed up some months after the original interviews.
3. In order to check for new interesting themes emerging from the research a findings-led analytical approach was employed. This entailed: brainstorming about the key themes raised in each case; coding themes; and re-reading case reports with the objective of identifying all company references to these themes, either convergent or divergent to the emerging themes.
4. Company case information was summarised to produce a profile of the company, the projects, the approach to project development and its importance in the context of other influences on project outcomes. This approach helped to extract information which was crucial for the testing of hypotheses and for building a reliable and valid explanation of the importance of teams for project outcomes.
5. Case information was then classified according to company size, the level of project innovation, team approach, team effectiveness, team satisfaction and technical and commercial success outcomes. Chapters 5-9 address classification issues, such as variations in perceptions of teams and the difficulties associated with the dynamic nature of the team, the innovation process and changing company circumstances.
6. Detailed case information was then used to explore relationships between the classification criteria. It was possible to test the hypotheses with qualitative information and with quantitative data using statistical tests.

In general, the intention was to build an explanation using the logic of matching patterns between theoretical explanations and the cases, by taking account of the typical, the exceptional and anything indicative of trends. According to Yin 'The final explanation is a result of a series of iterations' (Yin, 1989, p.114). This explanation is arguably more valid and reliable when the following is established (*ibid.*, 1989), which the research seeks to achieve:

- reliability of methods, i.e. case study protocol which was followed up in all cases (Sect.4.5);



- construct validity, i.e. good operational definitions and measures, multiple sources of evidence and a chain of evidence which establishes links between the research questions, research methods, data and conclusions;
- theoretical validity, i.e. confirmation of predicted values;
- internal validity i.e. confirmation of the nature of the causal relationship.

However, the following analytical issues need to be considered when interpreting the findings:

1. Team processes were indirectly observed which leads to a problem of inferences for interpreting research findings. According to Yin 'every time an event cannot be directly observed it involves inferences' (Yin, 1989, p.43). These inferences include both the interviewees' inferences and my own. The unit of analysis is the team members' view of the team approach.
2. Despite the focus on specific projects within organisations, the case information was often true of organisational approaches to innovation in general.
3. The impact of an independent variable such as a team, on dependant variables such as project success outcomes, cannot be directly established when there is a complex aetiology. Team approaches and success outcomes have a variance which is unquantifiable and success outcomes are not explained by one independent variable. According to Yin 'This lack of precision (i.e. non-statistical variance) can allow for some interpretative discretion' (Yin, 1989, p.113).

#### **4.8. Measurement Issues**

According to Yin 'To explain a phenomenon is to stipulate a set of causal links about it. ... In most studies the links may be complex and difficult to measure in any precise manner' (Yin, 1989, p.113). In order to explore causal links between teams and their impacts, it was necessary to measure their impacts. The development of innovative products and processes may be evaluated in several ways.

First, the effectiveness of resource utilisation is important, including resources of materials, capital equipment and time (Hayes *et al.*, 1988) as well as adherence to schedule

and budget (Ancona and Caldwell, 1987; McDonough III, 1990; Barczak and Wilemon, 1991).

**Second, technical performance** and progress towards project goals is important (McDonough III, 1990; Barczak and Wilemon, 1991). Similarly, Hayes emphasises design quality as a key evaluation criterion, which includes performance, aesthetics, cost and the extent to which the product meets the markets' requirements (Hayes *et al.*, 1988). The CBI/DTI report on 'innovation performance measures' differentiates measures of product from design performance; the former includes product-cost, technical performance, quality, return-on-sales and market share, whereas the latter includes manufacturing cost, manufacturability and testability (CBI/DTI, 1993).

**Third, the project cycle speed** is important which refers to the total elapsed time from the beginning of the project to the commercial launch (Hayes *et al.*, 1988; House and Price, 1991; CBI/DTI, 1993). This may be broken down into development-phase-time or time-taken-for-revisions (CBI/DTI, 1993) and other aspects of timing may be measured such as break-even-time (House and Price, 1991).

**Fourth, market success** is an important criterion for evaluation (Ancona and Caldwell, 1987). Commercial success has been measured by profits and sales, satisfaction and the degree to which the project enhances the career of those involved (Barczak and Wilemon, 1991).

While the level of project innovation may not always be a concern for the evaluation of projects within organisations, it is of interest to researchers on innovation. Empirical studies have had to rely on proxy measures of innovative activity such as inputs of R&D expenditures and activities or outputs such as patents (Acs and Audretsch, 1991). This is reflected in the measures of product and process innovation recommended by the CBI/DTI in their report on innovation which also includes measures of value to industry such as percentage sales/profits from products, numbers of anticipated product generations, market share for product innovations and the costs, quality and lead-times associated with process innovation (CBI/DTI, 1993).

The problem with input measures is that quantity does not indicate quality and indeed small organisations may be more efficient with resources (Yeaple, 1992) and therefore have higher yields for relatively small R&D expenditures. This supports the

inappropriateness of focusing on solely quantitative input measures. Furthermore, the problem with using patents as a measure is that there is a disparity between companies in their tendency to patent. Some companies prefer to keep their ideas a secret and avoid the time-wastage associated with patents (e.g. Biogentech and R&D Labs).

Table 4.2. Corresponding Academic Ideas On The Level Of Project Innovation

(Developed By Author)

5 point measure of technological change (Langrish <i>et al.</i> , 1972)	Outputs related to innovation stages (Freeman, 1982)	Levels of innovation (Piatier, 1984)	Classification of product changes (Hayes <i>et al.</i> , 1988)	Radicalness of innovation (Rothwell & Zegveld, 1978)	Levels of innovation (Walsh <i>et al.</i> , 1992)
5 - new technology & would require new text	basic research	radical novelty		radical break-through	radical break-through
4 - requires a rewrite of several chapters in standard text	inventive work	novelty	new core product or process	major technical shift	major product innovation
3 requires major change in 1/2 chapters or new chapters added	development of blueprints for new & improved products & processes		next generation of core product		incremental product innovation
2. requires few paragraph alterations	new type plant construction producing new, better or cheaper products	design, improvement upgrading or combination of old factors	addition to product family, add-ons, enhancements, component changes	improvement, imitation	design variants and new models
1 slight or zero change		old or traditional	no change		

When appraising the level of innovation using input or output indicators, it cannot be assumed that similarly rated innovations are homogeneous in terms of their level of innovation. Furthermore, it cannot be assumed that the market or technological value of patents and expenditures is a numerical constant when inter-project or inter-company comparisons are made. As a result of this, it was decided not to focus solely on the gathering of information on company expenditures and patents. Instead, the interview questionnaire was designed so that the level of innovation could be appraised on a scale based on the ideas of key academics in the field (See Table 4.2). The scale developed to appraise the level of project innovation in the interview questionnaire is clearly based on these combined ideas (Appendix 2).



In a study which explored the relationship between project performance and leadership characteristics, McDonough suggests that both project type and the level of innovation influence the appropriateness of different project evaluation criteria (McDonough III, 1990). He pointed out that the goal of new product development (NPD) is customer sales, whereas the goal of R&D is the development of technology which may later be used in NPD (*ibid.*, 1990). Commercial criteria are of greater relevance to the evaluation of NPD and the success of NPD is likely to depend on both a greater number of departments and market influences than technology development projects (*ibid.*, 1990). On project innovation, he pointed out that while measuring adherence to schedule and budget is helpful for evaluating incremental innovations, this emphasis may be counterproductive for more radical innovations, since careful management to budget and schedule can restrict creativity and may ultimately reduce the commercial success of a product (*ibid.*, 1990). Several companies such as Analytik and Biogentech supported the idea that an emphasis on time-to-market may reduce the innovative functionality of products, since these companies aimed to quickly launch a less innovative product and then supersede it with a more innovative later launch.

McDonough made some other interesting points on measurement which apply to this research project (*ibid.*, 1990).

**First**, it is difficult to measure project performance if projects are underway (*ibid.*, 1990). In the case of the present research, it was often difficult to measure the commercial success of projects which may take years to reach full sales potential.

**Second**, it is important to be guided by the success criteria valued by project teams (*ibid.*, 1990), since management will be optimised to address these priorities. For example, time-to-market was not a highly valued success criterion in several companies and it would be therefore inappropriate to emphasise its assessment in this research project. For example, in small companies such as Gulls Exports the innovative project was given a low priority because a long-term future was identified for the project and scarce resources were needed elsewhere for routine business activities. More innovative projects may expect to command a unique market position and compete more on originality than on beating competitors to market.

**Third**, not all apparently objective measures are objective in practice, for example, time-to-market and budgets may be incorrectly estimated at the beginning of the project and

frequently changed throughout the innovation development process (*ibid.*, 1990). In several cases, such as Wasserpur and Datalog, schedules and budgets were unnecessarily pressurised and later eased without any negative repercussions for the projects' time-to-market and market success. Inter-company comparisons cannot easily be made using measures of time-to-market and adherence to budgets because of the intra-company influences on estimates, although it is possible to make direct comparisons between similar projects, companies and sectors.

Fourth, another limitation of studies is that it is not clear how measures are combined and what weighting is given to different measures (See Barczak and Wilemon, 1991).

It was decided to rely more strongly on subjective evaluations given by team members for the following reasons:

1. Team members gave different priority to evaluation criteria.
2. There were difficulties in gaining explicit commercial outcome information.
3. The innovation process is dynamic and changing and there was the possibility that long-term commercial impacts would not be fully achieved within the time available to the present research programme.
4. There are difficulties in appraising 'objective' information on project outcomes objectively.

The questionnaires (Appendix 2 and 3) indicate the information sought on effectiveness and success outcomes. Team member evaluations were utilised as the ultimate measures of commercial and technical success and of team satisfaction and effectiveness. Other studies have used self-report measures of performance arguing that they are not necessarily upwardly biased to give an unrealistically good performance evaluation (Barczak and Wilemon, 1991). The validity of team member evaluations is supported by their foundation in feedback from the personnel, departments and companies involved with developing innovative products and processes, in addition to feedback from markets and customers.

The criteria adopted to measure success outcomes were as follows:

Technical performance - This is indicated by meeting the technical specification for product/process quality and performance, the satisfaction of customer requirements, compliance with government and EU regulations and team satisfaction with the performance and quality of the project.

Commercial performance - Projects are evaluated in terms of whether they fulfilled team member expectations for sales or profits.

Team satisfaction - This is indicated by team ratings of satisfaction with the overall team experience and the project results.

Team effectiveness - This is indicated by team ratings of effectiveness and willingness to work again with other team members.

#### ***4.9. Generalising From Findings***

According to Mintzberg, generalisation from research findings is important, since if no one ever generalised beyond their data there would be no interesting hypotheses to test because every theory requires a creative leap (Mintzberg, 1979). The research findings have an external validity for companies of different sizes operating in different industries, which are using team approaches to the management of both in-house or inter-company technological project developments of varying levels of innovation. The case study approach offers analytic or theoretical generalisability by testing existing theories or research. Case studies offer a wealth of insights into complex processes and ideas and suggest new lines of research enquiry. The present research was conducted with a relatively small sample of teams which means that further research would help to establish the statistical generalisability of the findings. However, the research findings offer qualitative in-depth insights into an important area of innovation management as well as interesting, useful ideas for further research on team processes, team effectiveness and the importance of teams for the success outcomes of innovative products and processes.



# Chapter 5 Company Teams

## ***5.1. Introduction***

The concept of the organisational team is presented in the literature as one where there is a fixed membership (See Katzenbach and Smith, 1993) and fixed boundaries (See Ancona and Caldwell, 1992), although Ancona and Caldwell admit that boundaries within organisational groups are never as clear as laboratory teams. The view of the team, as a relatively closed system with respect to membership, is so entrenched in the literature that the researcher assumed that fixed team membership and boundaries would be intrinsic to the nature of organisational teams. The research findings presented in this chapter suggest that this view requires re-consideration. Section 5.1 explores the extent to which team approaches were adopted by the organisations participating in this sample. Section 5.2 outlines team member perceptions of the nature of organisational teams. Section 5.3. considers the reasons for and implications of variations in team member perceptions of team size and membership boundaries. Section 5.4. considers how teams were formed and Section 5.5. considers what happened to teams in the post-project organisational scenario. Finally, Section 5.6. explores those circumstances when organisations decide not to adopt team approaches to developing innovative products and processes. This helps to clarify when teams are appropriate to innovation management.

## ***5.2. Team Use In Organisations***

The majority of companies participating in the present research adopted team approaches to some aspect of their business operations. Table 5.1 shows that of the 25 participating companies, 21 adopted team approaches to developing innovative products and processes <sup>1</sup>. Since 3 of the companies discussed two projects, 24 project teams were considered for analysis. Of the 4 companies which did not adopt team approaches to the development of innovative products and processes, 3 of them adopted team approaches to general business and routine projects.

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<sup>1</sup> It should be noted that company names have been changed to preserve the anonymity of the companies which participated in this research project

Table 5.1. Overview of Team Use By Companies

Abbreviations:

X indicates that a team approach was adopted

N indicates a team approach was not adopted

Company	Company size at the time of the innovative development	Type of innovative projects	Team approach adopted to innovative projects	Team adopted for routine business projects
Datalog	Medium	Water quality measuring product	X	
R&D Laboratories	Small	Water quality measuring product	X	X
Systems Engineering	Small Subsidiary	Plant to supply clean water	X innovative work conducted within contracts	X-
Wasserpur	Medium Subsidiary	Water purification product	X	X
Gulls Exports	Small	Plant to incinerate waste	N Mainly a single person project	
Effluent Treatment Systems	Medium Subsidiary	Sludge waste separation plant	N Mainly a single person project	
Filtratec	Small	(1)Water purification plant (2)Industrial effluent treatment by advancing membrane technology	X	X
Pollution Control Engineering	Small Subsidiary	Gas effluent cleaning treatment plant	X innovative work conducted within contracts	X
New Carbon Ventures	Medium Subsidiary	Re-activation of carbon water filters system	N	X
Sludge Treatment Systems	Medium	Anaerobic sludge digestion treatment plant	X innovative work conducted within contracts	X
Wind Power Projects	Small	Wind powered waste water treatment system	N	X
Water Services	Large Subsidiary	Water quality monitoring product using particle size analysis	X	X
Cheminstrum	Small	Product to measure impact of chemicals on environment	X	X
Analytik	Large Subsidiary	(1) Disposable environmental monitoring sensor (2) Effluent monitoring sensor	X	X
Robinson Engineering	Large Subsidiary	Secondary sewage treatment plant	X	X

Table 5.1. *Continued.*

Power-engineering	Large Subsidiary	Clean power generation plant using gasification methods	X innovative work conducted within contracts	X
CWT Engineering	Large Subsidiary	Effluent treatment plant	X	X
Sensorval	Small	Pollution detection in water product	X	X
EMS	Large Subsidiary	Environmental monitoring station product	X	X
Longman Engineering	Large Subsidiary	(1) Geographical information system for environmental hazard monitoring (2) Environmental monitoring in specific environmental areas	X innovative work conducted within contracts	X
Engineering Projects	Large Subsidiary	Warning hazard system for personnel safety	X	X
Biogentech	Small Subsidiary	Water quality monitoring product	X	Not applicable since it is a single project company
Water Quality Utilities	Large Subsidiary	Quality control of drinking water supplies	X	X
Greenwater	Small	Buildings waste water re-use system and water conservation project	X	Not applicable since it is a single project company
Innovconsult	Medium Subsidiary	Bio-degradable packaging materials	X	X
<b>Total = 25 companies</b>	<b>Total Small=10 Medium=6 Large=9</b>	<b>Total =28 projects</b>	<b>Total= 24 project teams, 4 non-teams</b>	<b>Total=20 companies using teams for routine work</b>

### 5.3. Definition Of Teams

Table 5.2. shows below that the team membership tended to be a smaller subset of the innovative project group membership which included all the members and expertise available for the innovative project development. Team approaches were distinguished from looser group and more formalised departmental approaches. The main characteristics of the team which were matched by the participating companies were as follows:

1. Two or more members;



2. Members contribute their competencies within interdependent roles towards shared goals;
3. A team identity, which is distinct from the individual identities of members;
4. Established norms for communications both within the team and with external groups;
5. A structure which is explicit, task and goal-oriented, organised and purposeful;
6. Periodical reviews of team effectiveness;
7. Purposeful leadership of the project;
8. Team life is usually limited to the fulfilment of team project goals.

The first six team characteristics above were drawn from a literature review by the author and another researcher (Mabey and Caird, 1994) and the remainder were appended by the author. An account given by one of the team members from Datalog presented an example of the way a team formed one year after the beginning of a development project and how this was marked by a profound shift of identity.

#### **Datalog**

‘Suddenly we weren’t part of the technical department, we were the Product X team. There was no change in desks, but shifts in feeling, maybe due to an isolationist policy, basically the common enemy’ (which was mainly the lack of support by the Directors and other functional groups within the Datalog). ‘When a group of people become a recognised team they start to feel an identity *outwith* themselves and actually identify themselves as part of a team and will do that willingly and subconsciously. In that environment, people will not be themselves but will become the superman. Their identity will fuse with the group. A kind of identity transition’. He was quick to say that he didn’t mean being absorbed by the group, but that team members would identify with that group more than others. He mentioned that the team development process was helped by ‘loyalty and commitment and accepting others frailties’. All of the Datalog team respondents gave credit to the role of the Development Manager in building the team. Although other staff in the organisation thought that the team members put in extra time on the project development for the money, one of team members pointed out that they did it ‘for ego and for team’.

Some other examples from company team illustrate how team members defined organisational teams.

Examples of definitions of teams given in Wasserpur show that managers from different functional backgrounds define teams similarly:

The Project Manager from Wasserpur said 'my understanding of a team approach is to assemble the right team, discuss the project, try and agree the goals and then work together to achieve the goals'.

The Laboratory Manager from Wasserpur said that the team involves 'collective discussions and a number of people with varied expertise in the project with a leader to co-ordinate and monitor goals and progress'.

The Marketing Director from Wasserpur said the team approach involves 'using the market and technical knowledge of all departments within a company to ensure that the correct product or service is being developed'.

Other Examples included the following:

The Technical Manager from **Analytik** described a team approach as a 'co-ordinated effort by the team members, each an expert in their own field, the skills of each complementing and supporting the others in pursuit of a common objective'.

The Division Manager from **Engineering Projects** described a team as a 'multi-functional group, each member of which has 'ownership' of specific aspects of the project, yet is required to co-ordinate activity with other members in order to ensure uniform progress with any interface problems'.

The Technical Services Manager from **Filtratec** described the team approach as 'using the different skills of each team member to move the project forward in a way that could not be achieved by team members with similar backgrounds'.

In addition to supporting many of the criteria in the definition of teams adopted in this research project, some of these definitions include references to the need for different functional representatives and groups to work together on innovative project developments.

#### ***5.4. Perception Of Team Boundary***

In 15 of the companies which adopted team approaches to innovative project developments, there was a response from more than one team member. In those cases therefore, there was an opportunity to consider perceptual differences on the nature of teams. Table 5.2. shows that there was either some perceptual variation or difficulty in estimating the team size in 12 of these companies. Interestingly, there tended to be less agreement about which functional groups and expertise was present within the team than the nature of the expertise available to the project in general. In other words it appeared that the team boundary may be a point of dispute within company teams.

Table 5.2. Variations In Perceptions Of Team Characteristics

Abbreviations:

S indicates similarity; V indicates variation;

D-indicates team members experienced some difficulty in estimation

Company	Team size	Team member expertise	Project expertise
Datalog	S	S	S
R&D Laboratories	D	S	S
Wasserpur	V	V	V
Filtratec	V	V	S
Pollution Control Engineering	D	V	V
Water services	V	V	V
Cheminstrum	V	V	S
Analytik	S	S	S
Robinson Engineering	V	V	V
Powerengineering	V	V	V
CWT Engineering	V	V	V
EMS	D	V	S
Water Quality Utilities	D	S	S
Greenwater	S	S	S
Innovconsult	D	S	S
<b>Total =15</b>	<b>Total 7V +5D+ 3 S</b>	<b>Total 9V+6S</b>	<b>Total 6V+9S</b>

Variation in the perception of important team characteristics made the task of classifying team approaches in Chapter 6 more difficult. It revealed the vague quality of company team boundaries, where often team size could not be specifically stated.

**Wasserpur**

In the case of Wasserpur, it was difficult precisely to enumerate the people involved in the project because some people worked full time and others part-time, some people were internal, others external and most worked on different aspects of the project which meant that team size varied through the project development.

Requests for information on team size tended to be met with some impatience, confusion and difficulty for several reasons.

**First**, projects were resource intensive and different staff, often from more than one company, were involved at different phases throughout the project development. This was the case for Wasserpur, Filtratec, Pollution Control Engineering, Water Services, Cheminstrum, Robinson Engineering, CWT Engineering, EMS, Water Quality Utilities and Innovconsult.

**Second**, in companies such as Powerengineering which attempted to integrate technology development with commercial operations, team size was difficult to estimate since the



innovative aspects of the company's clean power generation technology were continuously developed within different commercial contracts by several teams with overlapping membership.

**Third**, estimating team size can be difficult as team boundaries may shift during the project development process which was exemplified by the R&D Laboratories case.

#### **R&D Laboratories**

The R&D Laboratories case provided a good example of a shifting team boundary which revealed a soured relationship between the companies which had formed the inter-company team liaison. With the involvement of an industrial partner in the development of a water quality measuring product, the small R&D company embraced the bigger company within the team approach. But problems arose with the late discovery that their industrial partner had not set up a manufacturing contract for their products and had developed cold feet about the chemicals used in the products. This led to the partner's decision to adopt a reactive market stance and wait to see how the markets developed. This was accompanied by an attitude change and R&D Laboratories began to regard the partner's company as 'them' and their own staff as 'us'. The R&D Laboratories team then dwindled to nothing as the company fell into difficulties and laid off the staff who had formed the team.

A **fourth** difficulty in estimating team size was evident in some small companies like Cheminstrum and Filtratec where team boundaries were unclear because of the view that there was a company-wide team approach as well as a specific project team which represented a sub-system of the bigger company team system from which it drew resources. This was exemplified with the case Cheminstrum.

#### **Cheminstrum**

For one Director in Cheminstrum, this team approach included external design consultants and two other organisations which carried out work for them on electronics and mechanical engineering and manufacturing. He said 'if you hire outside you want people to feel part of the team' and they promoted this team approach through loyalty to suppliers rather than shopping around for a cheaper supplier. By contrast the Finance Director did not consider these external members to be part of the team, although he recognised their involvement with the project along with suppliers. His perception of the team was of a multi-functional team approach of staff who brought the expertise of electrical and software engineering, electrochemistry, marketing, sales, finance, production as well as the customers' viewpoint to the project.

There was also relative difficulty in gaining information on individual team members' expertise and distinguishing this from the expertise available to the project group in general. Intra-company perceptual variations of team size and members' expertise were greatest and team boundaries most blurred in the following circumstances:

1. When the project team was inter-departmental e.g. Wasserpur, Pollution Control Engineering, Cheminstrum, EMS and Filtratec.
2. When the project team involved drafting in different staff at different phases in the project development e.g. Wasserpur, Pollution Control Engineering, Water Services, Cheminstrum, Robinson Engineering, CWT Engineering, Powerengineering, EMS and Filtratec.
3. When there was more than one team participating in the team approach e.g. Wasserpur, Pollution Control Engineering, Water Services, Cheminstrum, Robinson Engineering, CWT Engineering and EMS.
4. When more than one company was involved in the project development e.g. Wasserpur, Pollution Control Engineering, Water Services, Cheminstrum, Robinson Engineering, CWT Engineering, EMS and Powerengineering.

By contrast perceptions of team size and members' expertise tended to be similar and team boundaries most clear in the following circumstances:

1. When the team was located within an organisational structure such as a department or small company e.g. Datalog, Greenwater, Analytik, Water Services Utilities and R&D Laboratories.
2. When other companies involved in the project development were perceived to be beyond the team boundary e.g. Datalog, R&D Laboratories and Analytik.
3. When the same staff were involved throughout the project development phases e.g. R&D Laboratories, Datalog and Greenwater.

In some cases, similar perceptions of team boundaries by team members were explained by the fact that they came from the same department within a company e.g. Water Services Utilities, R&D Laboratories and Datalog.

### **Datalog**

The Datalog case showed that team boundaries were clearly established within a single-disciplinary technical department. This single-disciplinary team emerged within a technical department and involved five staff with expertise in development engineering including the Development Manager who led the project. This team approach did not include marketing expertise which the Development Manager described as being 'almost out on a limb'. Neither did the team include purchasing expertise. Furthermore, although another company called Chemqual was involved as a joint development partner with the development of a water quality monitoring instrument, this was regarded as a separate team. During the course of the development work there were staff changes particularly in the marketing function in both companies. However, since the Datalog team boundary excluded both marketing expertise and the other company Chemqual, the team boundary remained unchanged and strong.

This was also applicable to Analytik because the core project team came mainly from one department even though they adopted a multi-functional team approach.

### **Analytik**

Product introduction teams became the standard way of approaching innovative product developments in Analytik. Although these teams were largely intra-departmental, they had a multi-functional base which was clear from strong communications with other departments at the early stages of project development. The team boundary was clarified by project memoranda which typically listed sales, marketing and publicity on the circulation list for team documentation.

Furthermore, perceptions of the team boundary and expertise were closer when the same staff were involved throughout the project development phases. This applied to several of the team members interviewed within R&D Laboratories and Datalog as well as the very small company Greenwater.

### **Greenwater**

In Greenwater the two Directors and only employees regarded themselves as the team. However, they distinguished between themselves and the team effort which included their wives who offered administrative support and ideas on the project as well as the other organisations who had been or would be involved with the development and sale of their water conservation project.

It appeared that perceptions of team boundaries were more varied when the team membership was more multi-departmental; when the disciplinary expertise required for the project generally and at different project phases was more varied; and when there was more than one team or company involved in the team approach. This implied that team boundaries were vaguer and more pervious in these circumstances. Furthermore, in cases where there were several departments, teams or companies involved there was usually more than one co-ordinator associated with the communications and it was likely that all



team members did not know what was going on or precisely which staff were involved at all times. This implies a different concept of the team in these organisational settings to that usually referred to in the literature where the team concept implies a relatively fixed membership all of whom know and interact with each other. The case of Wasserpur exemplified the nature of blurred team boundaries where it was not generally accepted by team members which functions and disciplines were part of the team.

### **Wasserpur**

Wasserpur's team approach to the development of a water purification product was an example of a team approach which spanned departments, disciplines and included an external design consultancy in the development work. The Laboratory Manager, the Electronics Development Manager and the Marketing Director agreed that the following expertise and functions were involved in the project as a whole: mechanical engineering, electronics/ electrical engineering, industrial design, marketing, sales and production. There was some but not full agreement or awareness of the involvement of the following functions in the project as a whole: chemical engineering, software engineering, analytical chemistry, finance, clients, suppliers and senior management.

However, it was clear that the team concept was narrower than that of all project associates and further scrutiny revealed that the Project Manager's concept of team membership mainly included the R&D effort. All agreed that the team included mechanical and electrical engineering expertise. Some but not all respondents included expertise in analytical chemistry, industrial design, chemical engineering and software engineering within the team membership.

However, the Marketing Director alone included marketing expertise within the team itself. Furthermore, the technical Project Manager regarded the marketing input as 'a smaller part of the team than the mechanical engineer who's doing the actual conceptual design work'. The differing perceptions on who was part of the team may suggest potential team building problems.

The main explanation for blurred and pervious team boundaries was the variation in perceptions of which functional staff were involved with the team. In some cases such as EMS and Engineering Projects the marketing staff had a dual perception of their role in the team. On the one hand, they regarded themselves as part of a multi-functional team approach where there were regular meetings between R&D and marketing. On the other hand, in both EMS and Engineering Projects the R&D team was regarded as 'the team' who were largely given a task to complete by the Marketing Directors who managed the team.

### 5.5. Origins Of Teams

Chapter 2 discussed different approaches to the management of innovative projects drawing distinctions between more formal, departmental, sequential approaches and more multi-departmental approaches which could involve the adoption of quasi-structures, such as teams. The informality of teams was supported by the scarcity of references to team use in organisational charts which implied that information on the teams in organisations was difficult to uncover from company information alone. Table 5.3. shows that 18 (86%) companies adopted team approaches in inter-company collaborative projects. Greatest insights into the origins of teams and their impacts came from the companies which either had undergone an organisational changeover to team approaches or had teams which emerged for the first time within the organisation. However, over half of the teams (62%) had used team approaches on previous project developments. Team approaches did not therefore represent a new organisational approach for the majority of companies.

Table 5.3 Origins Of Teams

Note: Sample size is 21, based on number of companies adopting team approaches in this sample

Company	Organisational changeover to team approach	Traditional organisational use of teams	First time emergence of team	Inter-company teams
Datalog			X	X
R&D Laboratories			X	X
Systems Engineering		X		
Wasserpur	X			X
Filtratec		X		
Pollution Control Engineering		X		X
Sludge Treatment Systems	X			
Water Services		X		X
Cheminstrum		X		X
Analytik	X			X
Robinson Engineering		X		X
Powerengineering		X		X
CWT Engineering		X		X
Sensorval		X		X
EMS		X		X
Longman Engineering	X			X
Engineering Projects		X		X
Biogentech			X	X
Water Quality Utilities		X		X
Greenwater			X	X
Innovconsult		X		X
<b>Total</b>	<b>4 (19%)</b>	<b>13 (62%)</b>	<b>4 (19%)</b>	<b>18 (86%)</b>

### **5.5.1. First Time Emergence Of Teams**

Three of the four companies with teams which emerged for the first time represented new companies which were formed in order to capitalise on the innovative work. The majority of emerging teams were instigated by senior management and thus represent top-down decisions within the organisation about the best way to approach innovative project developments. The exception was Datalog, an established medium-sized company with a departmental structure and no tradition of using team approaches. Within Datalog the team emerged not as part of a top-down management policy but as spontaneous teambuilding by the Development Manager, within the Technical Department.

### **5.5.2. Organisational Changeover To Team Approaches**

Four of the companies adopted team approaches that had origins in recent organisational change. These case studies illustrated the issues associated with the changeover to team approaches. Although Wasserpur encountered many team and project problems, the Project Manager was generally satisfied with the organisational change which had taken place about four years ago. This moved the organisation from a sequential approach to innovative project developments over to a multi-functional team approach by restructuring the organisation into profit centres which contained all the required resources. Senior management support was in place at Analytik, but they recognised that it would take staff time to work differently. Despite Analytik's adherence to the organisational change planning recommendations such as staff consultation, staff education of the need for change and staff involvement with incremental change (Quinn, 1980) they encountered both some project planning and staff alienation problems.

#### **Analytik**

The previous hierarchical structure in Analytik had not worked well because the attitude prevailed that different aspects of the business operations should not interact but simply pass work to each other, when in reality success depended on all functions working together to some extent. Furthermore, the use of committees to bridge the hierarchical, departmental structure led to a situation where decisions were made unproductively slow. The Design and Development Manager was instrumental to setting up a 'task force' to restructure the department and introduce product introduction teams in order to radically improve the time of products to market, a current competitive issue.



*Continued.*

However, it takes time for staff to work differently and since the organisational changes have been introduced slowly, they have a situation where new projects are organised with product introduction teams, whereas old projects are developed in the old sequential departmental way. Since multi-functional team approaches are more resource-intensive at the early stages, this can cause resources planning problems when the resource requirements for projects peak at the same time. This would be resolved in time as the projects developed the old sequential way would gradually peter out.

Fostering closer inter-departmental links by changing over to the use of multi-functional teams as well as removing organisational hierarchies had unsurprisingly created some reluctance at first. It left many staff with empty titles, creating a situation where 'those with the title manager do not manage anyone now'. However, efforts to change this attitude were being made through education and enthusiasm from the engineering department. The Design and Development Manager pointed out 'In engineering we are in the business of producing new products. In other departments they tend to be in the business of producing what they know. But once you sell someone an idea that you know will be a good one, they are usually responsive'. Some of the problems in the past have been that the engineering departments have thrust products onto downstream functions without any warning and then the barriers tended to go up. It had been relatively easy to implement these changes. 'Apart from the abominable snowmen', most staff have tended to support change because 'the pay-off is that they get to do the things they want to do quicker and more easily'. They hoped that the new approach would lead to a greater cross-fertilisation of ideas and greater inter-departmental and inter-disciplinary co-operation.

Problems with alienated staff following organisational change also featured in the case of Sludge Treatment Systems. However, it was clear that staff problems had obstructed the effectiveness of company operations prior to the organisational change and to this extent it was not a new problem. This case supports Pugh's fourth principal of organisational change which is that 'change is most likely to be acceptable ...in those people...who are basically successful in their tasks but who are experiencing tension or failure in some particular part of their work' (Pugh, 1978, p.143).

### **Sludge Treatment Systems (STS)**

STS moved from a matrix organisational structure with function heads at one vector and project managers at the other, to a team based project centre structure where the project managers became 'King' with access to all the design, engineering and administrative staff required for projects. This organisational change was inspired by recognition of the inefficiency of the matrix system, where function managers often obstructed the work of the project manager by not co-operating with the release of staff to work on projects, a scenario which ultimately reduced profits and repeat business.

These cases suggested that organisational changeover to team approaches were aimed to improve the effectiveness either of company operations or competitiveness. Generally, organisational change to team approaches created human resource problems, in the areas of staff relations and resource planning. This was particularly noticeable when the adoption of team approaches accompanied a change from a hierarchical organisational structure to a flatter structure leading to the alienation of those staff members left displaced or with empty titles. Some companies, such as Analytik implemented well-known recommendations for planning organisational change. Even when companies took on board these recommendations there were still some difficulties since it took staff time to accept and learn to do things differently. However, it was not easy to see whether or how displaced titled staff could be brought into a team approach, since their loss of power may be associated with their lowered organisational value. Formally instigated team approaches revealed the tendency for organisational problems to accompany the adoption of team approaches for the first time. Those excluded or who chose to exclude themselves posed management problems of integration at best and resistance to the team efforts at worst.

### ***5.6. The Organisational Fate Of Teams***

Further insights into the way teams were used in organisations may be drawn from a consideration of what happens to teams when the project finished. This appeared to be largely determined by whether or not the team came to be perceived as a system whose capability should be maintained for further project work. As Table 5.4 shows, when projects were completed, teams were typically re-merged into the organisational structure or structures. Eighteen of the 24 (75%) projects developed by team approaches were or were likely to be merged back into organisational structure as resources for future projects. In other cases, the teams were purposely destroyed or transformed into a new organisational structure.

The 18 companies which were merged back into the organisational structure included Longman Engineering and Analytik where there had been organisational change and Greenwater where the team included the only two employees. It also included companies such as CWT Engineering, Pollution Control Engineering, Cheminstrum, Robinson Engineering, EMS and Water Services where the companies involved with the inter-company team approach had worked together before and were likely to work as a team again because of the good relations between the companies involved. For these companies



the potential for new organisational structures emerging out the positive nature of the inter-company teams was apparent as a result of their emphasis on trust and co-operation.'

Table 5.4 Organisational Fate Of Post-Project Teams

Note: sample size is 24 based on number of project teams  
 Abbreviations  
 X indicates the destination of the team  
 XF indicates what was likely to happen to the team in cases where the project was not yet complete

Company	Team merged back into organisation	Purposeful destruction of team	Transformation of team into new organisational structure
Datalog	X		
R&D Laboratories		X	
Systems Engineering	X		
Wasserpur	X		
Filtratec	XF		
2 projects	XF		
Pollution Control Engineering	X		
Sludge Treatment Systems		X	
Water Services	XF		
Cheminstrum	X		
Analytik	X		
2 projects	X		
Robinson Engineering	X		
Powerengineering			X
CWT Engineering	X		
Sensorval			X
EMS	X		
Longman Engineering	XF		
2 projects	XF		
Engineering Projects	X		
Biogentech		XF	
Water Quality Utilities		X	
Greenwater	XF		
Innovconsult	X		
Total projects	18	4	2

CWT Engineering

In CWT the Senior Process Engineer emphasised the importance of a long standing co-operative relationship of at least twenty five years with their client and development partner, who they regarded as a ‘quality client’. He described the relationship as ‘not an adversarial relationship where each are trying to squeeze the most out of the other. We recognise the commonalty of our interests and therefore are willing to have a reasonable amount of give and take to the better satisfaction of both sides. It shouldn’t be the case that once a contract is signed you are at war with one another and doing legal battles all the time. That is not really constructive’.

This contrasted with the Datalog case where the inter-company liaison was unlikely to be continued for other projects.



### **Datalog**

Even though something of a team feeling remained within the team in Datalog, the team's inter-company collaboration was unlikely to lead to new cross company organisational structures. Although, the Development Manager from Datalog got on extremely well with his counterpart in the other company, the collaborative partnership was fraught at times when Datalog Directors encouraged their development team to think in exploitative one up-upmanship terms rather than promote a long-term co-operative relationship.

Some teams had a greater potential for re-formation within the companies involved and this was largely determined by the quality of staff relations. The importance of staff relations as a determinant of the post project potential of a team helped explain why two company teams led to the formation of new permanent and semi-permanent organisational structures. A joint venture team led to the formation of Powerengineering which continued the clean power generation project work. Furthermore, Sensorval's involvement with two companies in an inter-company development project was expected to continue for several planned future projects. Although some inter-company problems jeopardised Sensorval's continued inter-team approach, the potential for new product developments afforded by the liaison and the market potential for those products led to great efforts by Sensorval to make the collaborative team approach work well.

Staff relations were also an important consideration in the case of the four company teams which had been or were likely to be purposely destroyed. Staff relations were impaired by the destructive action taken by senior management which was likely to affect any potential for the re-formation of these teams. In R&D Laboratories, the teams were destroyed when staff were laid off following difficulties which left the company near liquidation.

### **R&D Laboratories**

The satisfaction of the team in R&D Laboratories had been very high and staff were described as highly motivated, fighting valiantly to the end. However, when most of the staff and some of the Directors were laid off without pay, there was 'a certain amount of sour grapes'. Despite this it was always understood that team members were contract workers whose contribution was project limited and they were expected to move on when the projects ended.

There were some similarities with Biogentech which had plans to terminate contracts with some of the teams involved, following completion of the development work.

### **Biogentech**

Biogentech had taken people on as company associates with short-term contracts, rather than recruit people formally into Biogentech. This ensured that this resource could be easily dispensed with before they reached the manufacturing phase. The Managing Director said that 'It is a sad reflection on the economy that you can pick up and dispense of very good people very easily'.

There were other reasons for the destruction of teams which also led to difficulties with the re-formation of teams. In Sludge Treatment Systems, senior management destroyed the team in order to reform organisational teams and spread out the recognised effectiveness of the team to the rest of the company.

### **Sludge Treatment Systems**

Sludge Treatment Systems underwent organisational change to a formal team organisational structure so that in theory team members were responsible to the Function Head, but accountable to the Project Managers. When it became clear that one Project Manager's team was outperforming the other teams, the Directors decided to break up the teams in order to spread the project management expertise located in the top performing team around to the other teams in order to raise the general level of team performance. The Project Manager said 'At the time I couldn't understand why the teams were changed, having established a good rapport and having been apparently successful. I thought you've just ruined a successful team'. However, he could see that it was best for the company to have more strong teams available, particularly for important projects, although later this never happened owing to company difficulties.

In Water Quality Utilities, senior management destroyed the team for different reasons. In this case this action was taken in order to generate innovation and energy in the teams which were perceived to be too cosy.

### **Water Quality Utilities**

Satisfaction with the team experience in Water Quality Utilities was such that there was something of a family feeling about the R&D team's approach to the development of greater quality drinking water supplies. The cohesiveness of the team helped them to be very focused on the project but they admitted that it may have left them blinkered to what was going on in the rest of the organisation. There was a certain amount of post-project floundering, characterised by an unreadiness for the transition to new projects and an inclination to carry on perfecting the project by attending to minor technical problems. As a result of this the 'cosy little teams' were broken up and new teams were set up in an effort to generate energy and innovation into new areas. This was described by one of the engineers as 'a major trauma'. He thought that 'they had broken up the teams too much, leaving them with too many managers trying to get too much out of members'. It appeared that although the team approach was effective and important for achieving project success outcomes, it was not so helpful in facilitating the transition to new projects and strategic directions.



The importance of the transition of the team to new projects or of team members to new teams had been emphasised as an important measure of team satisfaction (Hackman, 1990) and a recognised indicator of team effectiveness (Adair, 1983). If or when a team or project ended it would appear ideal that it should retain the potential to re-form for new projects. The management of this transition is particularly pressurised when teams are purposely destroyed leaving dissatisfied staff. However, it appeared undesirable that teams should become ends in themselves. Teams needed to be managed in order to facilitate the transition to new projects, teams or businesses if the potential was present.

### ***5.7. Non-Use Of Teams By Companies***

Four companies did not adopt team approaches to their innovative project developments. These approaches were arguably as diverse as the team approaches described in Chapters 5-6. Of these companies Effluent Treatment Systems was only the one to exemplify the sequential over-the-departmental-wall approach described in Chapter 2.

#### **Effluent Treatment Systems (ETS)**

The innovative idea for the development of a small belt press to process sludge came from the Managing Director of ETS, who saw the market niche. He passed the idea to be interpreted and designed by the R&D manager who worked alone on the design work before passing the design on to two sub-contractors to build a prototype which was then tested out on customer sites. The R&D Manager pointed out that sales only became involved when they think there is a product for them to look at. The R&D manager did not welcome much liaison with sales because it involved a lot of communication and time wasting.

Companies like Analytik and Wasserpur had up until recently adopted this departmental non-team approach before they underwent organisational change. By contrast, the companies Wind Power Projects, New Carbon Ventures and Gulls Exports adopted informal approaches to their innovative developments with inter-company networking. Informal approaches were an alternative to either the multi-functional team or the sequential departmental approaches. The case of Gulls Exports exemplified an informal approach to innovation development.



### Gulls Exports

Gulls Exports was a small company with a flat organisational structure in which power was strongly centralised in the Managing Director's role. Although the development of the waste incineration project involved extensive networking with several universities, potential partners, clients, government or other organisations, the approach adopted could not be clearly described. The Managing Director described their approach to project development as chaotic and crisis-driven and compared their activities to a 'flock of seagulls following carrion'. There was chiefly one person involved with the co-ordination, the R&D manager, although possibly all 25 employees were involved with the development project. Time pressures were not great and the Managing Director and R&D manager talked about the project informally from time to time. The project may take several years to commercialise fully since the project could only be tackled when general business was slack. They expected that it would eventually be a successful project and bring in 10% of turnover to the company.

The cases of Gulls Exports and Effluent Treatment Systems demonstrated that non-team approaches can be satisfactory for the companies involved. This raised the question of why team approaches are valuable for innovative project developments, especially in light of Adler's view that teams are the most expensive and time-consuming of the co-ordination approaches available for innovation management (Adler, 1992). In addition to the companies which did not adopt team approaches to innovative project developments, it was noticeable that the companies adopting team approaches to both innovative project developments and routine business projects, did not necessarily do so for *all* project developments. Team respondents from companies such as Analytik, Water Services, New Carbon Ventures and CWT Engineering explicitly stated that some very small projects did not require a team approach and could be easily handled by one person. The Technical Director from Water Services pointed out that decisions over the adoption of a team approach were determined by the following: the size of the project and budget and whether in-house skills were available. The bigger the project and budget the less likely that the required project skills were available in one person, department or organisation; it was then more likely that a team approach would be adopted. Furthermore, according to Water Services, the type of approach adopted was influenced by the technologies employed, the level of innovation, the involvement of universities and other organisations and the project's potential for commercialisation.

Further insights into the use and non-use of team approaches may be drawn from further analysis of the four companies which did not adopt team approaches to their more innovative project developments. The Managing Director from Gulls Exports represented the only company opposed to the idea of team approaches, even though he mentioned that

they had a company wide team approach. In reviewing the reasons why team approaches were not adopted, it was useful to consider the attitudes of this Managing Director who was actually antagonistic to such methods.

**Gulls Exports**

The Managing Director of Gulls Exports did not favour the idea of a team approach which involved ‘a common purpose’, because he did not think it would be easy to achieve. It conflicted with his personal theory of human motivation which was that everyone wants to do what pleases them and that the dominant members set the tone of the team. He saw himself as the dominant member and preferred accommodating people rather than equals. He regarded the team ideal as bureaucratic and socialist and regarded meetings as a waste of time. He held the attitude that ‘whenever more than two people are gathered together, then one of them is superfluous’. So he preferred an unstructured approach and had the tendency to allow one person to do everything whenever possible.

The Managing Director from Gulls Exports was not alone in these beliefs. Some of the respondents from companies which did adopt team approaches such as Water Services, Systems Engineering, Filtratec, and Analytik were also adverse to over-formality and bureaucracy in team approaches. For example the manager from Analytik was concerned that teams should not resemble committees where ‘people think they have come to an agreement but in fact everyone goes away thinking they have agreed something different. So things never seem to get resolved’. Furthermore, the belief of the Managing Director from Gulls Exports in the importance of dominant key staff was also shared by the Technical Director from Powerengineering, who was also opposed to team approaches which were too egalitarian. He was particularly adverse to the idea of marketing-led multi-functional teams, probably because it would threaten *his* dominant position and leadership role.

As Table 5.1 indicated, two of the companies which did not adopt team approaches to innovative project development actually adopted team approaches to their typical business, that is Wind Power Projects and New Carbon Ventures.

**Wind Power Projects (WPP)**

WPP adopted team approaches to the core business activities, and involved external consultants. When the project ended the team members were re-absorbed back into the company’s networks. However, the innovative waste-water treatment project, a major innovation which had won several government SMART awards<sup>2</sup> for innovation, was essentially a one-man project although at least four staff had become involved consecutively with the project development.

<sup>2</sup> The Small Firm’s Merit Award for Research and Technology (SMART) award is a government scheme to support small innovative companies. The SMART award is a regionally co-ordinated competition for innovators across Britain, who are having difficulty in attracting investment for high-technology projects.



The reason for the non-adoption of team approaches in companies like Wind Power Projects and Effluent Treatment Systems was less associated with antagonism and more to do with resource limitations, whereas for New Carbon Ventures, the non-adoption of a team approach reflected an oversight by senior management about the business potential of innovative work carried out by an engineer who was also working with another company. The case of New Carbon Ventures illustrated the potential benefits a team approach may offer and the business opportunities which were nearly lost when a looser, more *ad hoc* approach was adopted.

#### **New Carbon Ventures (NCV)**

NCV, a medium-sized subsidiary was a joint-venture between a water utility and an engineering company which was formed following the late discovery of the major opportunity represented by some innovative work on the re-activation of carbon water filters. The R&D work began within the engineering company which had no previous interest in the water industry.

There was no team approach, no project manager and the usual organisational procedures were not applied. Furthermore, the staff involved did not have a clear perception of where the work would lead. One key innovator operated solo in collaboration with a water company, until senior management recognised the opportunity to take the work forward within a joint venture business. He had a free hand and there was little concern about value engineering to maximise the marketing value of R&D work. The resultant innovation was of 'Rolls Royce' quality in functionality which made it difficult to sell, although it led to the formation of a successful joint venture.

Multi-disciplinary team approaches were adopted by New Carbon Ventures for routine business. Once the sales staff won the contract one of two alternative team approaches was adopted. The first called 'task-forcing' involved the formation of a team where all members worked closely and intensively together. The second approach was 'matrixing' which involved different departments working together but seldom meeting, using an internal mail system for communication.

This case shows that a team approach with senior management support from the outset might have led to an earlier recognition of the potential of the innovative work. Furthermore, a more organised approach might have made it easier to capitalise commercially on the innovation through 'value engineering' which would have supported cost-effectiveness in manufacture and price-linked product functionality. On the other hand, a more organised approach might have stifled the innovation and initiative of the key innovator and New Carbon Ventures might never have been formed.

The results of the research show that team approaches were frequently adopted by companies in this study and that when companies did not adopt team approaches to



innovative projects, it was often as a result of resource limitations, senior management oversight or a lower priority given to the completion of a more innovative project than to regular business projects. A team approach in the cases of Wind Power Projects and Effluent Treatment Systems was regarded as a luxury. However, companies such as Gulls Exports, Wind Power Projects and Effluent Treatment Systems were satisfied with a loose group approach or a mainly one-person operation when time-to-market was not of pressing concern. However, team approaches were not always appropriate due to costs and for small projects one person might better handle the project. Generally team approaches were valued with the exception of Gulls Exports. In conclusion, it appeared that team approaches were valuable providing they did not resemble committees and were not over-formal and bureaucratic, since this might lead to time wastage, lowered innovation and project ineffectiveness.

### ***5.8. Summary***

Team approaches were typically adopted by organisations in this sample for both routine projects and for the development of innovative products and processes, often involving inter-company liaisons. The use of teams was an informal aspect of organisational behaviour and despite organisational tendencies to adopt team approaches, teams were rarely mentioned on organisational charts. The majority of teams were set up by top management and it was rarer for a team to form as a result of the team building efforts of one member of staff. When organisational changes led to team approaches, there were usually human resource problems with staff relations and resource planning.

Typically when the project ended the team dissolved and merged back into the organisation or organisations from whence they came. However, inter-company teams which were managed with an emphasis on trust, co-operation and building long-term relationships retained the capability to reform in the future. Not all teams merged back into the organisation; some were transformed into new organisational structures which included new business formations and joint ventures. Furthermore, some teams were purposely destroyed when senior management wished to spread the value of the team to the company or because the team was not perceived to be as effective as expected. Teams were also destroyed when companies fell on hard times and were forced to sack staff. The organisational fate of teams shows that they were not ends in themselves but were set up with expectations for the project, the team members and the company. Since teams usually had a relatively short-term project focus, it was important that there was effective

management of the subsequent transition to new projects or teams. The effectiveness of managing the end of projects was evident from whether team members were empowered to work once again as part of a team on new projects.

When team approaches were adopted, it was often difficult to classify the type of approach because of the blurred, pervious team boundaries which were evident from perceptual variation amongst team members about boundary characteristics. There was usually broad agreement about the expertise associated with the project in general, although not for the team expertise, a subset of the associated project expertise. The main reasons for the blurred organisational team boundaries were due to the resource intensiveness of projects where different staff, often from more than one team, department or company, were involved with different phases throughout the innovation development process. By contrast, team boundaries were clearer when the team membership did not cross departmental or company boundaries, when the same staff were involved throughout the innovation development phases and when projects were routine business projects.

The implications of such blurred, shifting and pervious team boundaries for team operations and effectiveness are considered in greater detail in Chapter 10. They lead to difficulties in classifying team approaches in Chapter 6. From a research perspective, it may be the case that the less fixed the team boundary the more difficult it is to observe and analyse team roles and team boundary spanning operations. The inclusion of members in the team has implications for team operations, since team cohesiveness may be difficult to achieve when membership boundaries are unclear. The advantage of more fixed team boundaries with a more homogenous membership as with single-disciplinary teams includes greater ease with teamwork and cohesiveness (Ancona and Caldwell, 1992). However, fixed team boundaries may be disadvantageous in cases where excluded staff were not empowered to integrate and contribute relevant expertise to the development of innovative products and processes.

Opposition to the adoption to team approaches was based on concerns that teams should not resemble committees or be over-formal, thus wasting time and reducing project efficiency. A few companies mentioned some antagonism to the egalitarian team ideal. Another issue of potential concern was that teams may not draw equally on the competence of all members and may become dominated by particular members which may not be always appropriate for innovative developments. The main reasons why team approaches were not adopted by some companies to developing innovative products and processes



were associated with resource limitations, the failure to realise the potential inherent in a project or a low priority given to the completion of the innovative project.

Team approaches were typically adopted when projects were resource intensive and given a high organisational priority matched by budgetary and staff resources. However, the reasons for not having teams were not always associated with company limitations and anti-team perceptions; sometimes teams were not seen as the best approach, especially when the project was of a size that could be easily handled by one person. This supports Adler's view on the cost and time consumption of teams, which is greater than for other co-ordination approaches available for innovation management (Adler, 1992; See Section 2.2.5. for discussion of alternative co-ordination mechanisms).



# Chapter 6 Multi-Functional, Multi-Disciplinary And Single-Disciplinary Team Approaches

## 6.1. Introduction

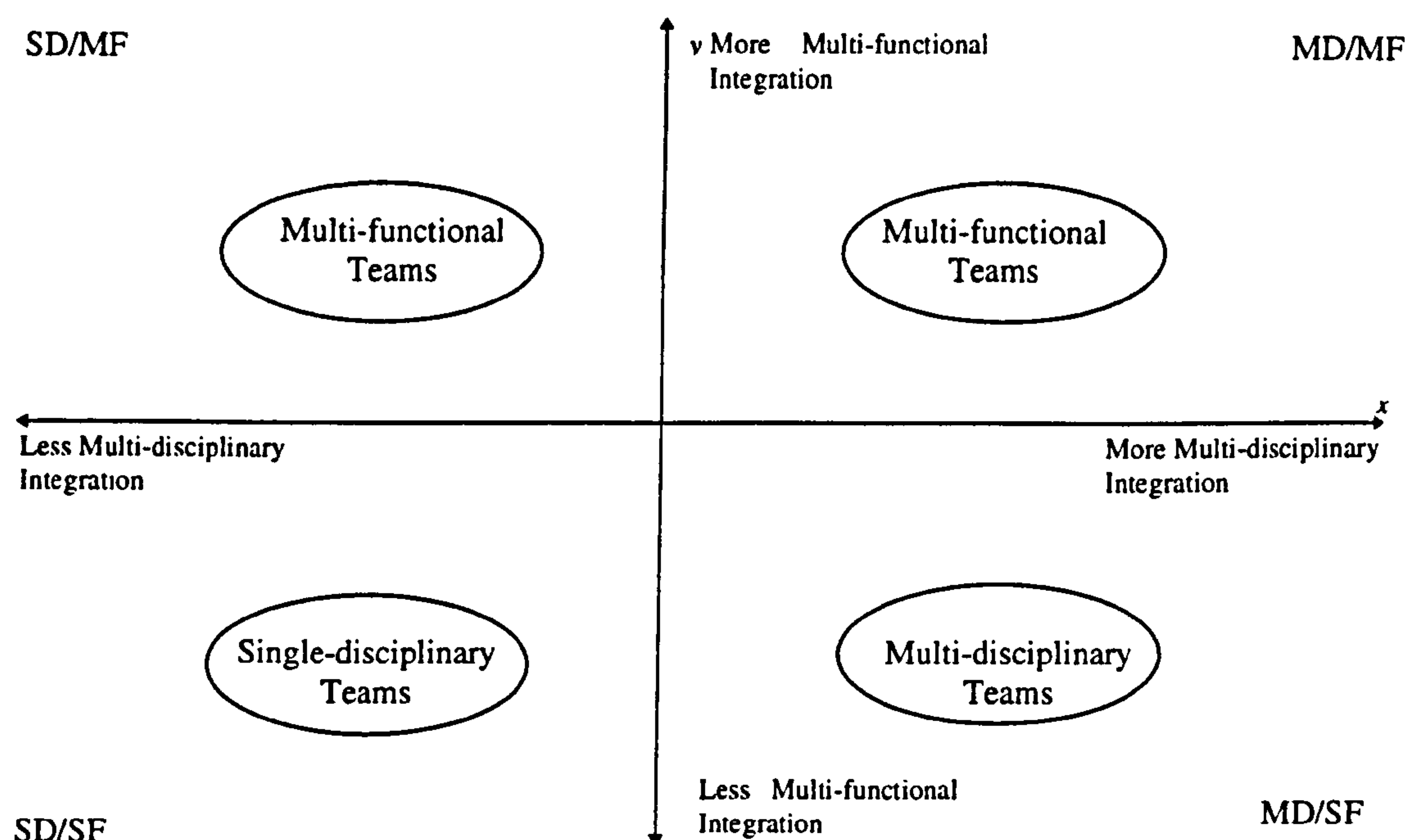
Chapter 2 distinguished between traditional linear approaches to innovation, based on passing a project from department to department, and more recent approaches, such as the new paradigm multi-functional approaches to developing innovative products and processes. Furthermore, Chapter 2 suggested that a multi-functional approach is essential for the development of innovative products and processes and that when team approaches are adopted, they will be differentiated by the extent of the integration of departments and of staff from diverse backgrounds over the development process. It further suggested that there would be several different team approaches, which could be more or less multi-functional and multi-disciplinary in nature throughout the innovation process. In Chapter 4, three main types of team approaches were identified. Whilst acknowledging the variability and diversity of organisational teams, the present chapter analyses cases of innovative project developments associated with all three, namely:

- **single-disciplinary teams (SDT)** which are dominated by a single scientific, engineering or technological disciplinary expertise and excludes business expertise;
- **multi-disciplinary teams (MDT)** which include staff who represent more than one scientific, engineering or technological disciplinary expertise but excludes business expertise from the team;
- **multi-functional teams (MFT)** which includes staff who represent more than one scientific, engineering or technological disciplinary expertise as well as business expertise.

Figure 6.1 illustrates the key distinctions between the three team approaches. Two types of integration differentiate the team approaches. **First**, the extent of multi-disciplinary integration of scientific, engineering or technological disciplinary expertise is represented by the X axis. Teams may be located on this dimension according to whether they are more (MD) or less (SD) integrated. **Second**, the extent of multi-functional integration of business functional expertise, such as sales, marketing, production and may include

purchasing, finance, law etc. is represented by the Y axis. Teams may be located on this dimension according to whether they are more (MF) or less (SF) integrated.

Figure 6.1 Team Matrix Of Organisational Team Approaches To Innovation



**X axis** - disciplinary integration - scientific, engineering or technological disciplinary expertise- teams may integrate more disciplines with multi-disciplinary (MD) integration or less disciplines with single-disciplinary approaches (SD).

**Y axis** - functional integration - business functional expertise such as sales, marketing, production, purchasing, finance, law etc.- teams may integrate more business functions with multi-functional integration (MF) or less functions with single-functional approaches (SF).

The three broad team types are illustrated as a matrix in Figure 6.1, presenting a new classification of team approaches to innovation which varies both in terms of multi-functional integration and multi-disciplinary integration.

**The Single-Disciplinary Team (SDT)** is represented in Figure 6.1 in the bottom left quadrant because it is typically dominated by a single-discipline and is intra-departmental



involving little inter-functional integration. SDT's are both single-disciplinary and single-functional.

**The Multi-Functional Team (MFT)** is represented in Figure 6.1 in the top quadrants because it integrates staff from different project functional backgrounds. However, in terms of scientific, engineering or technological disciplinary expertise, the MFT may be dominated by either single-disciplinary expertise or several scientific, engineering or technological areas of expertise. The MFT may be located at different points of the X axis including SD/MFT's and MD/MFT's.

**The Multi-Disciplinary Team (MDT)** is located in the bottom left quadrant of Figure 6.1 because it is typically has staff representing several areas of scientific, engineering or technological disciplinary expertise without integrating staff who represent the business functions, particularly sales and marketing, associated with the innovation process. MDT's are MD/SFT's and MD/MFT's are described as MFT's in this study.

Table 6.1. presents relevant intra-company and inter-company issues aiding the classification of team approaches. The majority of teams were integrated teams, since twenty project teams adopted either multi-disciplinary or multi-functional team approaches. The majority of companies (75%) worked with other companies. Furthermore, the majority of team approaches to developing innovative products and processes crossed departmental, disciplinary and company boundaries and required a liaison with other teams. An in-depth description and analysis of these team approaches offers insights into how these teams operated and why there were both intra and inter-company differences in the adoption of team approaches.



**Table 6.1. Examination Of Approach To Developing Innovative Products And Processes**

Abbreviations:

X indicates a team characteristic;

V indicates varied perceptions on whether a characteristic applies;

MF is Multi-functional; SD is Single-disciplinary;

MD is Multi-disciplinary; T is team; NT indicates a non-team approach

Company	More than 1 department in team	More than 1 discipline/ business function in team	More than 1 company involved with team approach	Nature of other teams involved with project	Classification of approach
Datalog			X	MFT	SDT
R&D Laboratories			X	MFT	SDT
Systems Engineering					SDT
Wasserpur	X	X	X	SDT	MFT
Gulls Exports			X		NT
Effluent Treatment Systems			X		NT
Filtratec (1)	X	X			MFT
Filtratec (2)	X V	X V			MFT
Pollution Control Engineering	X	X	X	SDT & MDT	MDT
New Carbon Ventures			X		NT
Sludge Treatment Systems		X			MDT
Wind Power Projects					NT
Water Services		X	X	MFT & SDT	MDT
Cheminstrum	X	X	X	SDT	MFT
Analytik (1)	X	X			MFT
Analytik (2)	X	X	X		MFT
Robinson Engineering		X	X	SDT & MDT	MDT
Powerengineering		X	X		MDT
CWT Engineering		X	X	MDT	MDT
Sensorval	X	X	X	SDT & MDT	MFT
EMS	X	X	X	SDT	MFT
Longman Engineering (1)			X	SDT	SDT
Longman Engineering(2)		X			MFT
Engineering Projects	X	X	X		MFT
Biogentech		X	X	SDT & MDT	MFT
Water Quality Utilities	X	X	X	SDT & MDT	MDT
Greenwater		X	X		MFT
Innovconsult	X	X	X		MFT
<b>Total = 25 companies 28 projects</b>	<b>12</b>	<b>20</b>	<b>21</b>	<b>13 companies involved with other teams</b>	<b>4 NT 4 SDT 13 MFT 7 MDT</b>

## 6.2. Multi-Functional Team Approaches

Twelve companies adopted multi-functional team approaches to developing 13 innovative products and processes. Of these, four companies were small-sized, three were medium-sized and five were large-sized. Table 6.2. classifies the companies which adopted multi-

functional team approaches according to their different characteristics, using information presented by all team respondents.

Table 6.2 Characteristics Of Multi-Functional Team Approaches

Characteristics of team approach	Engineering Projects	EMS	Wasserpur	Analytik (1)
Project co-ordinating function	Marketing	Marketing	Technical although co-ordination was shared with other functions	Technical although co-ordination was shared with other functions
Involvement of expertise at initial stages	Marketing, client	Marketing, sales, client	Marketing, technical	Marketing, technical
Integration of R&D	General involvement but low involvement after pre-production testing stage	Generally involved	Generally involved	Generally involved
Integration of marketing	Co-ordinating function with greatest input at initial and final phases	Co-ordinating function with greatest input at initial and final phases	Mainly initial & final phase	Mainly initial & final phase
Integration of production/construction engineering	Involvement at pre-production phase	Generally involved	Involvement after marketing & technical product specification	Generally involved
X indicates >1 team involved	X	X	X	
Non team project associates	Client	Sales, finance, production.	Sales, production, finance, clients, suppliers, senior management	Mechanical & chemical engineering, chemistry, marketing, sales, finance, production, customers, suppliers
In-house expertise held in team(s) involved with team approach	Marketing R&D, Production engineering, Applications & design engineering	Varied perceptions of multi-disciplinary or multi-functional expertise	Varied perceptions of multi-disciplinary or multi-functional expertise	Mainly industrial design
Number of companies involved	2	2	3	1
Source of Multi-functionality	In-house plus development partner for testing technical viability	In-house plus sub-contractor for production	In-house plus sub-contractor for design & suppliers	In-house



Table 6.2. *Continued*

Characteristics of team approach	Innovconsult	Sensorval	Cheminstrum	Biogentech
Time of greatest inter-functional Integration	Pre-production testing	Technical specification, Pre-production testing	Initial and final phases	Design phase, Pre-production, Production
Project co-ordinated by	Multi-functionally skilled co-ordinator	Multi-functionally skilled co-ordinator	Multi-functionally skilled co-ordinator	Multi-functionally skilled co-ordinator
Involvement of expertise at initial stages	Client & in-house multi-functional expertise	Sales, marketing, R&D, senior management, financial and legal advice	Sales & marketing, chemistry & mathematical modelling	Joint-venture partners, Marketing, chemistry, biology
Integration of R&D	Generally involved	Generally involved	Generally involved	Generally involved
Integration of marketing	Generally involved	Marketing function supplied by R&D Director	Marketing function was supplied by Applications Director	Marketing function was supplied by Managing Director
Integration of production/ construction engineering	Outsourced & generally involved	Generally involved	Outsourced & generally involved	Outsourced post development
X indicates >1 team involved with team approach	X	X	X	X
Non-team project associates		Sensorval	Cheminstrum	
In-house expertise held in team(s) involved with team approach	Marketing, business planning, finance, manufacturing, patent analysis, chemical analysis, project management	Marketing, R&D, chemistry, industrial design & packaging, product testing, production	Varied perceptions of multi-functional expertise	Chemistry, biology, administration marketing
Number of companies involved	3	3	3	3
Source of Multi-functionality	In-house with external client & manufacturing expertise	In-house with development partners & sub-contractors contributing technological expertise	In-house with sub-contractors supplying design, electrical & mechanical engineering & manufacturing	In-house with 2 companies supplying expertise in biology, chemistry, mathematical modelling & project testing
Time of greatest inter-functional Integration	Project feasibility testing	General	General	Initial phase



Table 6.2. *Continued*

Characteristics of team approach	Analytik (2)	Longman (2)	Greenwater	Filtratec (1)	Filtratec (2)
Project co-ordinating function	Technical although co-ordination was shared with other functions	Multi-functional co-ordinator	Multi-functionally skilled co-ordinator	Multi-functionally skilled co-ordinator	Multi-functionally skilled co-ordinator
Involvement of expertise at initial stages	Marketing, technical	Technical, client, marketing	Marketing & technical	Client, multi-functionally skilled staff	Multi-functionally skilled staff
Integration of R&D	Generally involved	Generally involved	Generally involved	Generally involved	Generally involved
Integration of marketing	Mainly initial & final phase	Marketing function was supplied by technically skilled staff	Marketing function was supplied by Managing Director	General involvement but mainly initial phase	General involvement but mainly initial phase
Integration of production/construction engineering	Initially & generally involved	Generally involved	Plans to work with suppliers for in-house production	Generally involved but mainly post development	Generally involved but mainly post development
X indicates >1 team involved					
Non-team project associates	Expertise from Analytik & external potential clients & suppliers	Potential clients	Spouses, potential clients & manufacturing companies	Expertise from Filtratec, client & external industrial design	Expertise from Filtratec & external mechanical engineering
In-house expertise held in team(s) involved with team approach	Mechanical, software & electrical engineering, chemistry, physics & design	Hardware & software development marketing, project management	Research, product testing, law, purchasing marketing, admin.	Mechanical & chemical engineering chemistry	Varied perceptions of multi-functional expertise
No. of companies	2	1	2	2	1
Source of Multi-functionality	In-house & development partner for testing technical viability	In-house	In-house & development partner for testing technical viability	In-house & client	In-house
Greatest inter-functional Integration	Initial & final phases	General	General	General	Initial product definition phase

Table 6.2. shows that multi-functional team approaches may be implemented in many different ways within companies. Multi-functional team approaches varied in terms of the following:

- the co-ordinator's expertise (Sect. 6.2.1);
- changes in the main co-ordination function (Sect. 6.2.1);
- the source of multi-functionality, which may involve one or more team or company and may be chiefly supplied by one person (Sect. 6.2.2 and 6.2.4);
- the number of disciplines and business functions involved with the project development;
- the nature and timing of staff interaction during the project development process (Sect.6.2.3).

#### **6.2.1. The Co-ordinator's Expertise**

The co-ordinator's expertise in multi-functional teams reflected the organisations' attribution of value to different types of functional expertise. In the cases of Wasserpur and Analytik, the marketing function worked alongside the R&D function as apparent equals, whereas in both EMS and Engineering Projects the R&D staff were clearly told what to do by the marketing staff. In EMS, R&D was located within a hierarchical marketing department and managed by the Marketing Director.

In smaller companies like Innovconsult, Cheminstrum, Biogentech, Greenwater, Sensorval and Filtratec, the project co-ordinators tended to possess a multi-functional expertise, and they multi-tasked on all phases of the project development, although all had come from a scientific or technical background. In Filtratec, all staff including the sales and marketing staff possessed either scientific or technical skills. While this might be expected in smaller companies where resources can be constrained, it was surprisingly true of Longman Engineering, a large company which, having fallen on hard times, had diversified into environment markets.



### **Longman Engineering**

This was a large engineering company which had fallen on hard times in the defence industry and subsequently diversified into environment and other markets for geographical information systems products. Although there was a marketing department within the company, it was not equipped to cope with the less guaranteed and shorter term contractual work available in the environmental area.

Organisational change to team structure and multi-functional teams assisted efforts to build multi-functional teams within the information systems department. The New Business Executive who had a background in mathematical modelling and software development had taken on a marketing role with this aim in mind.

The Applications Director from Cheminstrum expressed the importance of multi-functional expertise for individual team members as follows:

### **Cheminstrum**

The Applications Director pointed out that although most of the Directors were chemists, the main input into the project was not a chemistry input, even though the product was a chemical analytical test. He said 'You can't achieve what we have achieved if everybody works as a chemist because you need a team and so everybody has deviated away from pure chemistry in some direction or other'. One of the Director's had developed expertise in mathematical modelling and software. Another Director developed an expertise in the development of applications for instruments. A third Director who started as a bio-chemist had spent most of his career in sales and the fourth Director had specialised in finance and the legal side of the business.

The Applications Director went on to point out that multi-functional expertise was important for the project co-ordinator because of the importance of communication for project management. 'This is a very multi-disciplinary business. A chemist wants to get a result out of a scientific instrument which is, to most people, very obtuse. In order to make this instrument, a lot of engineering is required and the engineers usually know nothing about the chemistry or why it's important and the applications people don't know anything about engineering and you have to pull all this together. You've got to employ the right people who respect each other's position'.

### **6.2.2. The Source Of Multi-Functionality**

Multi-functional team approaches varied in terms of whether the multi-functionality stemmed from the presence of a wide multi-functional expertise within the team membership or whether team members operated in areas outside their original functional expertise. In some mainly smaller companies, such as Sensorval, Greenwater, Biogentech, Filtratec, Cheminstrum, Innovconsult as well as Longman Engineering, multi-functionality tended to mean multi-tasking across functional areas of expertise. Team co-ordinators in these companies multi-tasked in several areas of expertise sometimes in order to address the pressures of innovating in a small business context and sometimes because they enjoyed working in functional areas other than their own. These multi-functional team



approaches differed to those adopted in medium and large companies which were primarily co-ordinated by the marketing or technical functions and which had expert team membership. Team members in these larger companies may be discouraged from multi-tasking behaviour because this created a barrier to inter-functional integration, as in the case of Analytik. This suggested that in the smaller company the multi-functional team and its effectiveness was more likely to reflect the extensiveness of members' competency, whereas in the larger company the multi-functional team reflected the organisational structure and its contribution of expertise to the multi-functional team.

Multi-tasking across areas of functional expertise, typical of the smaller company's multi-functional team approach, may be necessary for the project as a result of resource limitations. However, for some team members multi-tasking and seeing the project through all development phases was a major source of job satisfaction in the cases of Sensorval and Innovconsult.

**Sensorval**

The R&D Director had a multi-disciplinary background in chemistry, soil science and microbiology. Furthermore, she multi-tasked across areas of expertise which included project management, R&D development and testing, production management and quality testing, negotiating contracts with collaborating companies, packaging and marketing. She pointed out 'It has been very exciting to see the project through and this is an opportunity that you would be unlikely to have in a bigger company. In this situation (a bigger company) you might be left fuming on the sidelines as someone takes over the project and ignores your recommendations'.

However, multi-tasking may raise concerns. For example the Director of Greenwater was concerned that multi-tasking should be limited so that you avoided straying into areas where you lacked expertise. He said 'if you work on your own too much, you find yourself doing things you don't understand and you end up wasting time'.

The source of multi-functionality also ranged from in-house, as in the case of Analytik's project (1) team and Filtratec's project (2) team, to high levels of inter-company dependency as in the cases of Sensorval and Biogentech. The source of multi-functionality in teams varied as a function of the expertise available within organisations. Furthermore, the nature of multi-functional expertise varied, as shown in Table 6.2. This meant that there was no standard multi-functional team. In some cases, different expertise was required for different project developments within the same company. This was the case with Analytik where the more innovative project (2) involved a greater number of

disciplines in the team. Furthermore, some members of teams differed in their perceptions of both team membership and team approach which was discussed in Section 5.4.

### **6.2.3. The Nature And Timing Of Staff Interaction.**

The complexity and variation within multi-functional team approaches was evident from an analysis of company case reports. Of the thirteen multi-functional team approaches to innovation, Greenwater was the only company in which all team members were continuously involved with innovative project developments.

#### **Greenwater**

This was a very small company which had been set up to launch an innovative green design commercially, following a three-year R&D testing and evaluation programme. All the project development, testing and marketing work was carried out by a father-and-son team, although they had begun to involve a third party with the pilot testing of the product.

In the other twelve cases of multi-functional teams, staff representing different disciplinary or functional expertise were not continuously involved with every phase of the product development process. These teams involved either the co-ordination of several single and/or multi-disciplinary teams or the occasional integration of other staff expertise into a team approach. These multi-functional teams were therefore not multi-functional in the continuously interactive sense often assumed of team approaches. Instead they often had more than one team, group or company involved and a regularly changing team membership.

For the majority of multi-functional team approaches, the co-ordinator tended to be continuously involved in all phases of the project development although team members were typically drafted in and out of the team. However, Table 6.2. showed that there were some exceptions as when the primary co-ordinating function changed throughout the project development, for example Wasserpur and Analytik. In these companies, project development was mainly co-ordinated by technical staff, although the co-ordination reins went to marketing and production engineering staff at times, as illustrated below.



## Wasserpur

The initial ideas for developing the water purification product came from the marketing department who were concerned that the cost and poor design of an existing product made it too expensive to compete in overseas markets. The Project Manager said that the emphasis of co-ordination changed during the project; marketing got the project moving at first, then the Technical Director agreed a specification, then the project manager and R&D team got down to the actual development work. Later marketing took over again with the product launch.

The Marketing Director identified the first phase of the project as the identification of the product need involving sales, marketing and services working together. He only mentioned the involvement of marketing with the next phase which was to develop the product brief, although the R&D project manager pointed out that R&D worked closely with the marketing department and they had regular marketing-led product planning meetings.

The next phase identified by technical staff involved feasibility testing and costing but was not mentioned by the Marketing Director. According to the R&D Manager the design specification changed a few times as marketing requested a low cost and high quality product which R&D regarded as 'impossible' and 'stupid'. At this time they held a number of meetings at which they discussed cost versus product quality issues. 'You get a wish list from marketing and they want the earth. We sit down and see what is possible, what is feasible, what things will cost and we get our ideas together and then discuss it, agree what is reasonable and identify what do they really want and where do they want to stop spending money'.

Beyond the point of developing the product brief, marketing and R&D worked independently. R&D worked to build rough prototypes from mechano-like sets, involving chemistry technologists with test work. This phase was described as product development by the Marketing Director who believed that the main contribution of expertise at this phase came from mechanical engineering, production and design, but not from marketing. However, there were different perceptions on the involvement of functional groups at different phases of the product development, including one team member who identified a contribution from marketing at this phase.

During this phase, R&D contacted an external design consultancy (of which they had prior experience) with a request to produce an innovative design. The design consultants took longer than expected to produce an outline design, although by the time they were six or seven months into the project they had a rough idea of the shape and the components. From then on they had an approved brief and spent the next six months developing closer prototypes, using Computer Aided Design. Towards the end of the project, a draughtsman became involved in designing and fitting the moulded components and metal applications ready for product release at an exhibition.



### Analytik

They adopted a formal multi-functional team approach which was led by a technically-skilled Design & Development Manager, who drew in other functional non-technical expertise to the teams, so that the project teams became temporarily multi-functional when it was appropriate to facilitate communication for project co-ordination and management. Once the product reached production, the only R&D involvement was to support the product through the usual change requests during its life cycle. Co-ordination was essentially passed over to production and marketing at that stage.

In other medium-sized and large-sized companies like EMS and Engineering Projects, there was an impression of change in the primary co-ordinating function. However, close examination of these cases showed that the marketing function retained the co-ordination power throughout but delegated project work to both R&D and engineering functions. By contrast, all of the small company project developments were co-ordinated by multi-functionally skilled co-ordinators who remained in charge throughout the project development.

Table 6.2. showed that inter-functional integration varied at different project phases for each company, but was greater at some phases than others. With the exception of EMS and Engineering Projects, the majority of projects had technical staff and R&D staff involved at the initial phases. Furthermore, with the exceptions of Wasserpur, Analytik and Filtratec, the marketing function was involved throughout the project development process in all companies. Production engineering staff were involved throughout the project development process in Analytik, EMS, Sensorval, Innovconsult and Cheminstrum but mainly involved midstream in Wasserpur and in the final phases in Engineering Projects, Biogentech, Filtratec and Greenwater. Despite inter-company variation, the greatest inter-functional integration generally took place at the initial or final project phases. The majority of projects were co-ordinated by staff with a multi-functional expertise, although in some cases the co-ordination function was shifted between functions and in other exceptional cases, such as EMS and Engineering Projects, the marketing staff co-ordinated the project development.

Further insights into why inter-functional integration occurred and how different disciplinary and business functional representatives worked together in project development came from brief descriptions of multi-functional team approaches in Engineering Projects, EMS, Wasserpur, Analytik, Innovconsult, Cheminstrum and Filtratec.



### **Engineering Projects**

This case illustrated the point that staff associated with the project were not continuously involved with all phases of the project development. The team approach to the development of a safety monitoring device was a multi-functional team approach in the sense that they had regular formal meetings, with good communications between the team who worked together in the same room, while contributing different expertise at different phases of product development. However, the R&D team of two development engineers were also regarded as 'the team'. Although marketing led the project, the R&D team were largely given a task to complete and their involvement faded away at the pre-production stage. The approach involved the co-ordination by marketing of single-disciplinary teams which dominated different phases of the innovation process.

### **EMS**

This case of a medium-sized company, showed that inter-functional integration and the implementation of a multi-functional team approach may be largely an informal process. The in-house proximity of the different staff involved with the team process facilitated informal interaction with the result that 'people are always chatting together'. There were some formalised product development monthly meetings, but since people were always in the office, informal communication was more important than formalised meetings. Marketing led R&D on the development of an environmental monitoring project by setting market specifications which were derived from a knowledge of markets, customer requirements and legislation. When the technical interpretation of the marketing specification was agreed by marketing, the project became chiefly an R&D team effort. Marketing had a hands-off approach unless there was a problem or deadlines were missed. When the product got closer to market, there were links up again between marketing and R&D and the marketing team would start producing literature on the product for the launch. However, throughout the development of the product, they worked closely with an external electronics producer, an ex-EMS employee who had set up in business. This team approach was a marketing-led co-ordination of interacting single-disciplinary teams including marketing, R&D and an external electronics production team.

### **Filtratec**

Filtratec's more innovative project (2) exemplified how informality in small organisations allowed for a small dedicated single-disciplinary team to concentrate on R&D work in the context of a multi-functional team. In this small company projects were organised informally and typically each function within the organisation was involved with new project developments. The Technical Director pointed out 'We naturally adopt a multi-functional team approach...communication is easy, we can shout across at each other when we need to'.



## **Wasserpur**

A more formalised multi-functional team approach was evident which was concerned with increasing documentation and certification of their approach to projects like the water purification product development project. Wasserpur had re-structured the organisation within profit centres each of which tackled different product markets. This was essentially a multi-functional structuring of human resources since each profit centre had some elements of a matrix structure with general support departments such as administration, finance and R&D providing a back-up to the development and marketing of water purification products. This facilitated a multi-functional team based approach where sales & marketing were involved from the start and the situation could be avoided where they had a product that was wonderful but too expensive. This approach had become more formalised and controlled with increasing documentation and with increasing concern to tie specifications and secure early agreement between all those involved with the project. The Project Manager believes that it is important that 'everybody is happy that what we produce as design output was what went in as design input 12 months ago'. The Project Manager pointed out that 'the old days of the fag packets are over and we've really got to get down and document things properly'.

This multi-functional team approach involved several multi-disciplinary and single-disciplinary teams, including a multi-disciplinary R&D team. Other teams which participated with the multi-functional team approach included several single-disciplinary teams including marketing, an external design consultancy and production engineering teams. The project manager mentioned that the R&D team held regular progress meetings on the project 'The core people were always there and we used to call in the others as and when required. Minutes were taken, circulated etc. so that we kept people informed'. So rather than being a single team adopting a multi-functional approach, this involved several interacting teams, becoming temporarily multi-functional to facilitate communication for project co-ordination and management.

## **Analytik**

Analytik adopted a formal multi-functional team approach led by a technically skilled Design & Development Manager, who drew in non-technical expertise to the teams when it was appropriate. Thus the project team became temporarily multi-functional to facilitate communication for project co-ordination and management.

Project teams with a multi-functional base had become the standard way of approaching innovative product developments in this company. Although there was no set structure to project team management, there was a weekly meeting to review all current projects and otherwise meetings took place on a needs-be basis 'as the



*Continued.*

work dictates'. The team approach was multi-functional in the sense that all functions were involved in all communications on the projects. However, a typical team membership list placed the sales, marketing and publicity functions on the circulation list rather than under the list of team members which suggested that the multi-functional team approach involved essentially single or multi-disciplinary teams which had strong communications with other departments and functions.

The two environmental sensor projects under discussion were run concurrently with some overlap in team membership. The composition of the team changed throughout the product development process, but generally they aimed to involve staff representing more functions as early on as possible in the development process, rather than wait until close to the production phase. This helped them to fix the specification before production. Following production, the only R&D involvement was to support the product through the usual change requests during its life-cycle.

### **Innovconsult**

This case exemplified how a multi-functional team approach integrated client expertise with in-house expertise. The project under discussion referred to project development work on the use of bio-degradable polymers which was conducted on behalf of a pharmaceutical company. The client came to this medium-sized innovation consultancy with what seemed to be an unsuccessful technology but which was subsequently transformed for the client into a growing twenty million dollar business.

Initially when the client came to them with a problem, scientific and engineering staff members brainstormed together to identify a better technical solution for the client's problem before they established technical and marketing specifications. In the early stages, they also outsourced for their manufacturing requirements and planned the inter-face with the clients. The team members planned the overall scope of the project and agreed a broad work programme for each phase of the project with the client before moving to the conceptual inventive stage. They believed that they tended to get it right 'by spending time with the planning process at the initial stages and securing full agreement from all parties, including marketing, purchasing and manufacturing'. Once Innovconsult had analysed the technology and appraised the marketing opportunities, they moved onto a two-year development programme, during which there were approximately five sub-project teams with project managers from both Innovconsult and their client's company. Eventually the project was handed back to the client in the form of a new business.

It is interesting to consider the culture of this organisation which offered opportunities for staff to be entrepreneurial. The company was non-hierarchical with a matrix structure, although the most important way they managed the business was through projects using multi-functional team approaches. The company was described as 'a machine for doing projects...a high energy environment...a bit free-wheeling and sometimes on the edge of control'. Employees were expected to take



*Continued.*

the initiative in winning contracts and worked on projects from start to finish which was very motivating. One manager said 'The major stress put on people is generated by themselves. Here managers have to watch people to make sure they do not overload themselves'.

They strongly distinguished between the initial technology development stage and the later product development stage, the former being both more inventive and more difficult to manage than the product development phase. The innovation occurred largely in the technology development phase and could be time consuming, but profitable since it could lead to numerous new product applications. Typically the company favoured a hands-off approach at the early inventive phases recognising that it could take a day or a month to come up with a good idea, although they usually came up with a rapid prototype. By contrast, successful product development needed to be carried out quickly to get out onto the market. One manager said that 'the engineering aspect of a project can be extensively analysed, planned and managed by and large according to plan whereas the management of innovation will be less easy to plan and will involve dead ends'. Nevertheless, they pointed out that there was no clear split between the phases, but a gradual change of emphasis.

They attributed their effectiveness in rapid product development to inter-disciplinary team working, a strongly project-driven business and concurrent working on innovative development projects. 'Inter-disciplinary working... is the source of our innovative approach. In this way we can offer maximum value to our clients, that is a truly innovative approach which involves thinking outside the tunnel vision that normally besets our clients.'

### **Cheminstrum**

This case exemplified how a small company networked extensively throughout the project development process to bring in required expertise. The identification of the market for this chemical analysis product came from the sales operations of Cheminstrum's sister retailing company and led to the formation of Cheminstrum. Initially, a mathematical modeller worked almost alone on this project for several months and made a breadboard, a wooden instrument with a circuit board to prove that they had a feasible concept. Marketing and finance staff helped to establish the feasibility of the project and at that stage they knew that to turn it into a product they required skills which they lacked in the fields of industrial and electronic design. They therefore involved a design consultancy which helped them to design the product ergonomically and aesthetically. Realising that they didn't have the money to bring the project forward to a prototype stage, they applied successfully for the DTI SMART award <sup>1</sup>.

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<sup>1</sup> The Department of Trade & Industry's Small firms Merit Award for Research and Technology (SMART) is available for small firms with technologically innovative ideas that are far from market.



*Continued.*

The Applications Director disliked being too directive and structured because 'in this innovative field, you don't really know what you want, so it is not a good idea to be too hard and fast about the exact specification at too early a stage'. At the manufacturing stage they were concerned to fix the specification. In developing a working model and prototype they also involved the end user before moving the prototype into production. Finance, mechanical engineering and suppliers were involved at the production stage and finally marketing, sales and scientific expertise were involved to bring the product to its first product sales.

#### **6.2.4. Involvement Of Several Teams**

Of the 13 company teams which interacted with or incorporated other company teams, 5 adopted multi-functional team approaches, including Wasserpur, Cheminstrum, Sensorval, EMS and Biogentech. Section 6.2.3. has explored the way inter-functional integration occurred in Wasserpur, Cheminstrum and EMS. Further insights into the way teams may interact as part of a multi-functional team approach come from the following examples of Biogentech and Sensorval.

##### **Biogentech**

This case illustrated that a multi-functional team approach may involve little inter-functional interaction between several teams when the co-ordination of the team approach is centralised in the co-ordinator's role. This type of multi-functional team approach was appropriate because there were several teams from collaborating companies which were constrained from meeting frequently by lack of resources and proximity. This very small year-old, technologically innovative company was set up as a joint venture to commercialise rapid diagnostic technology which came from a cross-fertilisation of ideas from physics, micro-biology and immuno-chemistry. Although Biogentech only officially employed two staff, the company co-ordinated work from three organisations, including a University and the two shareholders.

The project was developed with the Managing Director acting as the co-ordinator of five multi-disciplinary and single-disciplinary teams, involving about 30 people, most of whom were not employed by Biogentech. The first team was multi-disciplinary, composed mainly of biologists and one physicist working in liaison with university academics to conduct a feasibility study. Unlike the development teams which became later involved, this was an innovating team in the sense that although the goals were set, the methods were open. The work conducted by this first team led to the formation of a joint-venture Biogentech to work on the commercial exploitation of the technology. The second was a university based multi-disciplinary team, with mainly physicists and computer modellers who worked on the development work. The third and fourth teams were both laboratory-based development teams of graduate biologists working on different product applications. These were more conventional single-disciplinary development teams which were directed on a day-to-day basis with specific targets and expected to obey instructions rather than to innovate. The fifth team worked on the implementation and validation



*Continued.*

of the technology. At the time of the interview these teams had not met each other but were co-ordinated by the Managing Director who did a lot of business mileage to meet his co-ordination responsibilities. Although there were plans to introduce all the teams to each other, there had been no necessity or benefit for them to meet before.

The Managing Director adopted a time-based marketing strategy when he realised there was the potential to develop a less innovative product which would help them to both make a better time-to-market and create a market for future more innovative products which they could later launch. This meant that they worked on parallel technological applications for the technology and each of the projects was at a different stage. The Managing Director said 'It is important to put something out there that works, as opposed to something with bells on that works, if the bells are going to cost you another 3 months and you have lost 3 months of market share'. However, although they were under enormous pressure to get a product to market, they had the advantage that the competitor technology did not come close to Biogentech's innovative capacity.

### **Sensorval**

This case exemplified how a small manufacturing company set up and maintained an inter-company collaborative development project with two other company teams. This brought together technological and scientific expertise in analytical chemistry, microprocessing technology and sensor technology for the development of an environmental testing product. The project originated in Sensorval where the R&D Director pointed out that 'there comes a point in R&D when you have to think about the next generation of products...when you see developments outside there in the world but you have not got the internal expertise'. Rather than attempting to recruit this expertise into the company, they set up a collaborative venture with two other companies, each representing key areas of technological expertise.

Typically the Managing Director, as well as sales, marketing, finance, R&D, technical and legal staff, were involved in the initial product specification. The R&D Director thought that this was important because 'it is typical of a small company that you start selling the thing before you have developed it'. The next step involved setting up the collaborative arrangement with the two other companies.

Apart from the involvement of sales, marketing and the Managing Director at the early market specification stage, the multi-functional expertise came chiefly from the R&D Director who co-ordinated the project development work of three multi-disciplinary teams. The Sensorval team was multi-disciplinary but included mainly development chemists. The Sensorval team contributed the functions of commercial product development, promotion and initial marketing, chemistry research and quality testing. The other two teams involved each had some development and manufacturing expertise as well as scientific and engineering expertise and so were essentially multi-disciplinary teams. Although 'everyone knows everyone' these



*Continued.*

teams rarely met, but were co-ordinated by Sensorval's R&D Director. Although she said that she would like to think of them as one team, actually it was more like being the co-ordinator of three teams, which sometimes pulled in different directions. Her co-ordinating role with these teams was vitally important as she not only contributed a multi-disciplinary expertise to the teams but operated to achieve the multi-functional integration required to bring the product to market.

There were greater requirements for inter-functional integration and team interaction than expected. The R&D Director said 'Right back at the beginning I thought I would handle it by hands-off management with meetings every couple of weeks and keeping regular contact and daily telephone contacts'. But they did not make much progress this way because one of the collaborating companies failed to meet deadlines. Sensorval then adopted a more hands-on approach and moved some of the development work in-house in order to make up lost development time and to bring their major innovation to market in good time. The approach to co-ordination changed and the project became more tightly controlled with plans, objectives and deadlines set regularly.

So the concept of the multi-functional team covers a wide diversity of approaches, often involving several teams and companies as well as representing staff with different functional backgrounds. The staff and teams involved with the team approaches might work sequentially, interactively or in parallel at times. The non-continuous involvement of team members and teams in multi-functional team approaches may be explained by the additional experimental developments associated with innovative projects which tended to bring unpredictability into project planning and timing and made it sensible for teams, single-disciplinary or multi-disciplinary, or staff within the team to work separately from time to time. The team members associated with multi-functional team approaches tended not to be continuously involved with the project and did not always interact with all other team members involved with the same phases, although communications were maintained. Despite this, some companies maintained informal continuity of information such as EMS, Filtratec, Greenwater and Cheminstrum, and others maintained more formal continuity, such as Analytik by sending memos for the information of project associates. This emphasised the importance of the co-ordinator's role and it was particularly evident in the cases of Biogentech and Sensorval that the project's success depended on the co-ordinators' operations.

### ***6.3. Multi-Disciplinary Team Approaches***

Seven companies adopted multi-disciplinary team approaches to innovative project developments, of which 5 were large-sized, 1 medium-sized and 1 small-sized. Four of these projects were initiated by clients and either wholly or partially funded by clients.

Like multi-functional teams, multi-disciplinary team approaches embraced different disciplinary functions which were not all recognised as part of the team by all team members. Table 6.3. classified the companies which adopted multi-disciplinary team approaches according to their different characteristics.

Table 6.3. Characteristics of Multi-Disciplinary Team Approaches

Abbreviations:

MF is Multi-functional; SD is Single-disciplinary;

MD is Multi-disciplinary; T is team.

Characteristics of team approach	Pollution Control Engineering	Powerengineering	Water Services	CWT Engineering
Project initiated by	Client	Client	Technical	Client
Project co-ordinated by	Technical	Technical	Technical	Technical
Involvement of expertise at initial stages	Client, contractors & technical expertise	Technical & scientific expertise, senior management & external financial organisations	Technical & Scientific expertise	Technical & client expertise
Integration of R&D	Generally involved	Generally involved	Generally involved	Generally involved
Integration of marketing	Pre-project development involvement	Initial marketing with potential clients	Initial marketing with potential clients	No project involvement
Integration of finance	Initial and final phases	Initial pre-feasibility phase		
X indicates >1 team involved	X		X	
Project associates	Senior management, software engineering & external sub-contractors for manufacturing, main building contractor, client & suppliers	Finance, marketing, project engineers, draughtsman	1 SDT scientific University team & 1 MFT product development team	Legal expertise, mechanical & electrical engineering, laboratory skills, marketing
In-house expertise held in team	Varied perceptions of MD or MF expertise	Varied perceptions of SD or MD expertise	Varied perceptions of MD or MF expertise	Varied perceptions of MD expertise including chemistry, mathematical modelling, chemical & software engineering, industrial design, production, suppliers & end user
No. companies involved	5	2	3	2



Table 6.3. *Continued.*

Characteristics of team approach	Water Quality Utilities	Sludge Treatment Systems	Robinson Engineering
Project initiated by			
Project co-ordinated by	Technical	Technical	Technical
Involvement of expertise at initial stages	Technical	Technical	Technical, client
Integration of R&D	Generally involved	Generally involved	Initial involvement of R&D then carried forward by development
Integration of marketing	No project involvement	No project involvement	Initial marketing with potential clients
Integration of finance			
X indicates >1 team involved	X		X
Project associates	Construction & operations engineering, suppliers & other companies	Sales	R&D, sales, marketing, electrical & software engineering, end user, research organisation client, suppliers
In-house expertise held in team	MD R&D skills, mainly chemical engineering	Civil, mechanical & electrical design skills, commissioning and process engineering, purchasing, administration	Varied perceptions of MD or MF expertise
No. companies involved	>2	1	5

Five projects were either wholly or partially funded by clients. In these companies, the sales staff passed the contractual work on to multi-disciplinary teams. Two projects were initiated in water utility companies which intended the innovative work to benefit their internal operations and enable them to meet EU Directives on water quality. The client-funded projects were initiated by sales or marketing and the two projects which were intended to benefit internal company operations, involved multi-functional expertise derived from several companies when the potential for commercialisation became evident.

All of the multi-disciplinary teams were co-ordinated by technical staff, once the project was passed on by marketing and sales staff who mainly operated at the initial pre-project development phase.

## **Robinson Engineering**

In this case business typically flowed through the company from the sales staff who produced proposals for contracts. When these bids were successful the company appointed a project manager to organise disciplinary inputs. This could involve all engineering disciplines and suppliers who were then invited to quote for prices. Typically a multi-disciplinary task-force was established under project management which was drawn from different departments.

By contrast, in-house R&D work was not the preferred approach for acquiring technological capacity in a big engineering construction company, since this would take too long for the company to make an impact on markets which might change quickly as a result of political action and legislation enforcement in the environmental area. The company preferred to develop their innovative capability by focusing on specific markets and then follow up new developments and patents with a view to licensing established and proven technologies. So their innovative work involved greater liaison with external organisations than their more routine business.

The primary sewage treatment technology project developed by Robinson Engineering (UK) was a licensed technology which had been developed by an Australian Research Institute. Robinson Engineering negotiated an exclusive license to use the technology which led to further development and validation work carried out in parallel by both Robinson (Australia) and Robinson (UK) with each subsidiary agreeing to share the findings on the development testing. The multi-disciplinary team approach was described by the Technology Development Manager as follows 'In taking the technology through the various stages, there are so many interfaces you have to get over. You have to get from your development people, through to your engineering people, through to your sales people through to your client. If you can build a team with inputs from these groups you can ease the path of the technology through the stages it has to get over'.

In the early stages, they liaised with sales and marketing and R&D. R&D tested the feasibility of the concept for the UK geographical and climatic context. Robinson UK set up a collaborative agreement with a water utility with which they have had a long standing technology agreement, in order to fund and pilot test two development plants jointly.

This was in line with their philosophy to involve the end user as soon as the project is protected and involve them with the expensive validation phase which precedes commercialisation, thereby reducing costs and bringing on board the views of a potential end user. Working closely with the water utility company they achieved promising technical results following design, field tests, and development testing. The development work was conducted by an inter-company team and included expertise in mechanical, chemical, electrical engineering, suppliers and the end user.



*Continued.*

The Technology Development Manager's concept of the team referred to the staff who were involved with the development and testing work within Robinson Engineering and the water utility. Outside the team boundary were the R&D staff who were involved with initial lab. tests, the sales and marketing staff consulted early on and the Robinson (Australian) development staff, although there was clear collaboration in the sharing of ideas, data and results.

Generally, the marketing function was weak within multi-disciplinary team approaches. However, this was not necessarily a problem for either client-funded project teams or projects intended to benefit internal operations. It was more of a potential concern when the company attempted to develop project developments commercially for a wider customer base. The case of Water Services illustrated how a water utility company attempted to capitalise on an internal development water quality monitoring project by involving three teams from several organisations.

### **Water Services**

Water Services was a large water company operating in the post-privatisation phase with a relative monopoly position in a mature industry. Although the water quality monitoring project under discussion was intended to benefit internal operations, the company was interested in the potential to extend its commercial operations into non-regulated more profitable markets and maximise their investment. Since privatisation, where possible, they attempted to pass on relatively tested innovative ideas to be sold as commercial products by their subsidiary companies.

According to the Technical Director, the regulated markets were more challenging technically while the unregulated markets were more challenging commercially. 'The water business is all about cutting costs and the technology business is all about making money.' They were still on a learning curve since it was not traditional to their operations to be concerned with turning processes into products and launching them commercially on open international markets.

During the development of this project there were three separate teams: a university team which was mainly single-disciplinary; the Water Services team which was mainly multi-disciplinary; and the subsidiary team which was multi-functional and commercial in orientation. The project was initially led by Water Services but later co-ordination was handed over to the subsidiary company to be marketed and commercially launched as a product. This left Water Services with an informal role following a long hand-over phase.

With the exception of Sludge Treatment Systems, Table 6.3. showed that multi-disciplinary teams involved more than one company in all cases. Pollution Control Engineering illustrated how several multi-disciplinary teams from 5 companies worked together on the development of an effluent treatment development project.



### **Pollution Control Engineering**

The project added effluent treatment functionality to a sub-contracted construction project. There was a client-led team including the main contractor and several sub-contractors. There was also a multi-disciplinary team within Pollution Control Engineering. According to the project manager, the team approach was like a double pyramid with the teams coming together as one led by the client via their project manager representatives.

Like multi-functional teams, multi-disciplinary team approaches involved drafting in different disciplinary expertise at different project phases.

### **Water Quality Utilities**

This water company worked on the development of a water purification process to improve the quality of water supplies and address a pesticide problem. Initially, there had been a degree of collaboration on a national programme with other water companies and a research centre. The identification of the problem was initially worked on by scientific and engineering staff. Then in collaboration with the engineering department the R&D staff explored possible methodologies which could be adopted to address the water purity problem. This was followed by some pilot testing to evaluate the application of various treatments and their costs. During this phase they discussed the project with suppliers, other companies, manufacturers and consultants. The next phase involved small scale trials conducted in parallel with a research centre. Bigger scale pilot testing was then conducted which led to a liaison with a construction engineering company to work on the commission and construction of the plant. This project was described as a multi-headed project because the co-ordination changed from R&D in the initial phase to engineering during the development phase and later to external construction engineering companies when the project was scaled up and commissioned.

## **6.4. Single-Disciplinary Team Approaches**

Four companies adopted single-disciplinary team approaches to innovative project developments, of which 2 were small-sized, 1 large-sized and 1 medium-sized. Table 6.4. classified the companies which adopted single-disciplinary team approaches according to their different characteristics.

All of the companies which adopted single-disciplinary team approaches to innovative developments were led by technical staff. Although all companies claimed to have identified a marketing niche, marketing staff were typically excluded from the team. The single-disciplinary teams in Systems Engineering and Longman Engineering were similar to the client-funded multi-disciplinary teams in the sense that the marketing function operated prior to the establishment of a project team to work on client-funded projects. As with multi-disciplinary client-funded teams, the project managers of single-disciplinary



client-funded teams typically attempted to win repeat business with established clients, which suggested a certain amount of multi-tasking activity outside the technical work:

The companies Datalog and R&D Laboratories were involved with projects directed at open markets, although the initial marketing involved little more than the Directors' having an idea which they then discussed with a few potential customers. The marketing function was supplied intermittently and mainly by another company in both of these cases.

Table 6.4. Characteristics of Single-Disciplinary Team Approaches

Characteristics of team approach	Datalog	Systems Engineering	R&D Laboratories	Longman Engineering (1)
Project co-ordinated by	Technical	Technical	Technical	Technical
Involvement of expertise at initial stages	Technical	Client, Technical	Technical	Technical, Client
Integration of R&D	General involvement throughout project	General involvement of development staff	General involvement throughout project	General involvement throughout project
Integration of marketing	Intermittent involvement but mainly supplied by partner company	Pre-project involvement	Supplied by partner company during initial phase	Pre-project involvement
Integration of production/construction engineering	Final phase involvement with R&D	General involvement	Supplied by partner company at initial phase	General involvement
X indicates >1 team involved with team approach	X		X	X
Non team project associates	Marketing, purchasing, sales, production, senior management & partner expertise	Systems engineering staff, including sales, finance, administration, client	Directors with marketing, &, production expertise supplied by partner	Contractors
In-house expertise held in team	Engineering, technical	Chemical engineering & technical	Chemistry, project management & technical	Hardware & software development & project management
Number of companies involved	2		2	>2

## Datalog

This established, traditional medium-sized manufacturing company diversified briefly into environment markets with a water quality monitoring product. The project originated in a meeting between the Managing Director of Datalog and the vice-president of an American company Chemqual which led to a decision to pool their respective expertise within a joint venture. This was a diversification for Datalog involving new markets and so they entered the joint venture with a reliance on Chemqual's marketing strength. One of the engineers working on the Datalog team said 'It was not exactly market-led, the two heads involved thought that it would be a good idea to share their expertise and fortunately a market sprang up'. Initially, they aimed at the American market, but later sought to address the UK market.

Unfortunately, within Datalog the marketing staff were described as being 'almost out on a limb'. The weakness of the marketing function was compounded by staff changes in the marketing function which meant that for three years the project ran without a marketing person.

The original idea was to join existing products with probes, a prototype described as the 'Octopus', which the Datalog team thought was very user-unfriendly. The first effort was to re-design the two products. However, using market intelligence, the Datalog team became aware that the product would not satisfy the UK market in terms of functionality. With little senior management support the project co-ordinator eventually persuaded both companies to design a product with a marketable functionality that would allow for extra functionality to be built in later if appropriate.

Chemqual's team approach was more multi-functional than Datalog's team since marketing staff directed their team and were involved from the outset of the project. The strength of Chemqual's marketing function was such that they brought a significant contract opportunity in the UK to the attention of Datalog, even though Datalog was based in the UK unlike Chemqual which had both a US location and market orientation. Up to the point of manufacture there were regular meetings and beyond this point, meetings were held as required to address issues such as pricing, product problems and customer problems. Initially there had been a lot of support from Chemqual until there was a change in project priorities. At the time of the interview neither company was spending the money because officially the project was 'dead', although Datalog was still working on modifications.

In R&D Laboratories, a single-disciplinary team worked with a more multi-functional team from the partner company which they relied on to supply marketing expertise. This created a power differential between the companies, leaving R&D Laboratories with marketing problems and the threat of liquidation.



### **R&D Laboratories**

This was a small research and development-oriented company which worked on the development of an environmental safety water monitoring product. The Technical Director pointed out that the expected enforcement of environmental legislation led the company to adopt 'a proactive stance' on project development. The original ideas came from the Managing Director for both projects who initially approached potential customers and set up a partnership with a large company.

As an R&D company they relied almost totally on their bigger industrial partner to address the marketing and manufacturing of their project to the extent that the company had no marketing personnel, until the end when they employed a part-time Marketing Director. This liaison with a larger enterprise was originally perceived to be advantageous for this company because it provided access to a large customer base and an international market for their products. However, the intention was also that R&D Laboratories would liaise with a third party manufacturer and market their products through that avenue.

They had regular meetings with staff from the partner company, both R&D and marketing staff. At one point it might have been regarded as a multi-functional inter-company team approach, but when things began to go wrong within the joint-venture, R&D Laboratories began to regard themselves as 'us' and the staff associated with the partner's company as 'them'. Problems arose with the late discovery that their industrial partner had not set up the expected manufacturing contract for their products and had developed 'cold feet' about the chemicals used in the products and the high prices charged.

The staff on single-disciplinary teams were involved continuously throughout the project development. Single-disciplinary teams working on projects directed at open markets were characterised by situations where the team leader had little co-ordination power outside the team but instead needed to negotiate with staff holding project associated expertise. This was the case with Datalog which adopted a departmental sequential approach to project development and had inter-departmental problems.

All single-disciplinary teams had access to other areas of functional expertise. Three single-disciplinary teams were involved in collaborations with other company teams which helped to bring greater multi-functionality to the team approach. Both R&D Laboratories and Datalog worked with multi-functional teams from other companies. Although Datalog appeared to adopt a traditional departmental, over-the-wall approach, their collaboration with another team from another companies gave a less than traditional flavour to the team approach. Longman Engineering also worked with single-disciplinary teams from other organisations.



## **Datalog**

The project team was so rooted within a department that one team member said 'We were left alone for about 3 years to get on with it and given little or no back-up from anyone higher up, including the Technical Director and the other Directors. They took a back-seat until the thing was ready to go to production'. Morale was low in Datalog and one team member described the organisation as a 'headless, leaderless organisation that is led by middle management'. The culture was attributed to the departure of a charismatic leader who 'goes away leaving a lot of nodding heads, they've been trained to nod their heads and that is what they do'. The Directors tended to be involved on a day-to-day basis but this was associated with a low delegation of authority and responsibility to the managers. For the project development team, this created problems. As one team member said 'when it comes to crucial decisions, you tend to find that the Directors are not available: they are on holidays, have other things to do or aren't interested'. One team member thought that this was a disease of British industry which has 'no will to devolve authority and a strong will to devolve responsibility'.

This slowed down project progress and made inter-departmental work sometimes impossible. Datalog was structured along departmental lines with development staff reporting to the Technical Director. There were inter-departmental problems with marketing, sales and purchasing functions within the organisation. During the development phase the team co-ordinators purchased the required parts. But when the product was in production there was a reluctance on the part of purchasing and sales to purchase the parts themselves and they kept channelling that work back to the development team. This meant that the development manager couldn't get any other work done and was 'just pushing paper'. The infrastructure was not there to facilitate communication between sales, production and purchasing and the Development Manager had no authority to instruct sales to set up purchasing arrangements themselves.

There were also problems with a weak marketing function and a high staff turnover. Furthermore, one team member talked of the entrenched positions of marketing and engineering, being nothing like a united team effort. 'For a lot of projects the specification and demands tend to drift, the goal posts move all the time. You set off in one direction and half way through you are pressurised by sales or finances to change direction again. So all the estimates of time and resources become totally distorted...and what you are trying to build becomes completely different'. All team members perceived that they succeeded despite the company.

## **Longman Engineering**

The first project under discussion was a geographical information system which addressed national environmental safety issues. This was estimated to have involved thirty-person years, several teams and approximately twenty companies. This was originally entirely funded by the governmental client organisation, although at a later



*Continued.*

stage they invested considerably in this project in order to retain the intellectual property. Within Longman, the team mainly included staff with expertise in software and hardware development. The teams grew to a size of approximately sixty people at its peak, 50% of which were contractors brought in to push the project forward. There tended to be well-defined channels of communication established by the project managers which made management easier than open access within and between the teams.

## **6.5. Summary**

Multi-functional integration is essential for the development of innovative products and processes. This does not have to take place within the team and the team boundary may exclude associated project expertise, particularly in the case of single and multi-disciplinary teams. Both single and multi-disciplinary teams tended to be co-ordinated by technical staff, whereas multi-functional teams tended to be co-ordinated by either marketing or technical staff and often by staff with multi-functional expertise. Single-disciplinary teams tended to involve continuous interaction between team members who were involved with all phases of the innovation development process. Multi-functional and multi-disciplinary team approaches tended not to be associated with continuous interaction between team members. In some cases of multi-functional teams, the project co-ordinator was the only team member to remain involved throughout the whole innovation development process. Instead most of the team members and project associates were drafted in and out of the project, sometimes working interactively, sequentially or in parallel with other functional groups or teams throughout the innovation development process.

The team approaches described in this research programme were complex and often involved more than one team or company. Furthermore, there were significant inter-team differences on when, how and why inter-functional integration occurred. The complexity and diversity of team approaches stemmed from the fact that they often involved more than one team or company. When multi-functional team approaches involved more than one team, these teams were often multi-disciplinary or single-disciplinary teams dedicated to working on specific aspects of the innovation development process. In these cases, these teams were multi-functional by virtue of the co-ordination power of the project leader.

Both single-disciplinary and multi-disciplinary teams tended to have a weak marketing function. This was not a problem when the teams worked on either internal projects or client-funded contracts, when sales had already secured the contract. Such teams were



most appropriate for client-funded or internal projects. However, a more multi-functional team approach could benefit approaches to client-funded projects, since the involvement of sales staff could help to identify client satisfaction and promote repeat business. For the projects intended to benefit internal operations, a more multi-functional team approach would be beneficial if teams became interested in the commercial potential of the innovative project.

It became obvious that single-disciplinary team approaches targeted at uncertain markets excluded relevant business expertise from the team, particularly marketing. A low, intermittent or late involvement of marketing and other business expertise or the reliance on another company to supply this expertise was a problem for single-disciplinary teams. This was particularly a problem if relations were bad with the staff or companies representing the excluded expertise. While single-disciplinary or multi-disciplinary team approaches may suffice for client-funded or internal projects, multi-functional teams were more valuable for development projects directed at open markets.

Although inter-company collaborations may help to supply expertise that is not available in-house and facilitate a multi-functional team approach, the research suggested that innovating companies were in a stronger position if they could supply the core business expertise in-house rather than for example, rely on a partnering company for product marketing expertise. The majority of companies which set up inter-company collaborations drew on their partners for required scientific, technological or engineering expertise rather than for marketing or other business functional expertise. The risks for the innovating company appeared greater when they relied on a partner for marketing expertise and when financial risks were not shared, although it may not be always possible for small companies to avoid this situation.

Comparisons between single-disciplinary, multi-disciplinary and multi-functional teams support the appropriateness of multi-functional team approaches for integrating business expertise with scientific and technological expertise, especially when projects are directed at open markets. However, the findings on multi-functional team approaches raise questions about the most effective way to use multi-functional teams which varied in terms of:

- the project co-ordinator's expertise;



- the source of expertise and its availability and whether the team was composed of experts or members who multi-tasked both within and outside their area of specialist expertise;
- the type of expertise in teams and companies involved;
- the number of teams and companies involved;
- whether the primary co-ordinator and co-ordinating function changed during the innovation development process;
- whether, how and when inter-functional integration occurred amongst project associates.

Since multi-functional team approaches often integrated smaller teams, both single or multi-disciplinary, and tended to draft staff in at different phases in the innovation development process, this emphasised the importance of the co-ordinator who often had expertise in several disciplinary areas. The nature of the team approach changed throughout the development process. This suggested that the different role of the co-ordinators was key to differentiating multi-functional from single-disciplinary and multi-disciplinary team approaches. The requirement to examine the co-ordination of the innovation process as a whole rather than just focusing on the activities of a team is supported by the fact that 15 of the companies involved more than one team within the team approach and 21 of the companies obviously worked with other companies on the innovation development process. It is also supported by the different opinions of team members on the membership and size of the team which suggested that boundaries were blurred and pervious in the context of a dynamic, development innovation process.

This research shows that the new paradigm multi-functional team approach to the management of innovative product identified by Hayes *et al.* was not the only type of innovative multi-functional team approach to co-ordinating different functional representatives involved with innovation developments (Hayes *et al.*,1988). In particular, the Hayes concept of multi-functional teams does not include the idea of a team approach involving several sub-teams and companies. Furthermore, there were different types of multi-functional team approaches and it was not clear that all could bring the expected benefits to the innovation process. Chapters 7, 8 and 9 offer further insights into the best practice for using organisational teams and the significance of multi-functional team characteristics for team effectiveness and project success.

# **Chapter 7 Influences Of Firm Size And Level Of Project Innovation On Team Approaches**

## ***7.1. Introduction***

Chapter 2 suggested that approaches to developing innovative products and processes are primarily influenced by level of project innovation, firm size, organisational structure, the companies involved and the nature of the markets. The influences of level of project innovation and firm size are considered here in Chapter 7. Chapters 5 and 6 have explored the nature of team approaches adopted within an organisational structure. Chapter 9 later considers the influence of markets on appropriate team approaches and the importance of the team for project success.

Chapter 2's review of the literature suggested that while multi-functional teams are appropriate to large firms, their appropriateness to medium-sized and small firms as well as in inter-company collaborative projects requires exploration. If multi-functional teams are appropriate to small firms, it is likely that they will differ from larger firms with respect to team operations and are also likely to be more informal, with more multi-tasking by members. Section 7.2. addresses the question of whether firm size influences the team approaches adopted by companies.

Chapter 2 also suggested that different types of team may be appropriate to projects of varying degrees of innovation and that technological innovation may require organisational innovations, such as the use of multi-functional teams. Section 7.3. explores whether projects which varied in their level of innovation were co-ordinated differently.

## ***7.2. Associations Between Firm Size And Team Approaches***

Although the sample was too small to test statistically for associations between firm size and the type of team approach adopted to developing innovative products and processes, Table 7.1. shows that of the 11 small company projects, 6 companies adopted multi-functional team approaches to developing innovative products and processes. Three medium-sized and 3 large-sized companies also adopted multi-functional team approaches. Thus firms of all sizes adopted such approaches. Single-disciplinary team approaches were less commonly adopted by companies participating in this research, whereas multi-disciplinary teams appeared to be more typical of the large company. However, it is clear



that firm size was not associated solely with single, multi-disciplinary or multi-functional team approaches to developing innovative products and processes.

Table 7.1. Association Between Company Size And Team Approach

Company Size	Small <50	Medium 50>250	Large >250
	R&D Laboratories, Systems Engineering, Gulls Exports, Filtratec(1&2), Pollution Control Engineering, Wind Power Projects, Greenwater, Cheminstrum, Biogentech, Sensorval	Datalog, EMS, Effluent Treatment Systems, New Carbon Ventures, Sludge Treatment Systems, Wasserpur, Innovconsult	Water Services, Water Quality Utilities, Analytik(1&2), Robinson Engineering, Powerengineering Technologies, CWT Engineering, Longman Engineering(1&2), Engineering Projects
<b>Total- project teams</b>	11	7	10
Non-team approach	2	2	0
Multi-Functional Team Approach	6	3	4
Single- Disciplinary Team Approach	2	1	1
Multi- Disciplinary Team Approach	1	1	5

Although multi-functional team approaches were adopted by companies of different sizes, the implementation of this approach differed between small, medium and large companies. In the cases of Filtratec (project 1), Cheminstrum and Greenwater, all small companies working on in-house developments, there was evidence of less formality in the team approach than in the larger company multi-functional teams. This can be understood because smaller companies do not have the rigid departmental divisions which may hinder communication between different functional staff in larger firms (Sect. 2.4).

However, not all small companies adopted a less formal approach to co-ordinating multi-functional teams. In the cases of Biogentech and Sensorval, greater levels of formality were required because several companies were involved with the development work. It appeared that multi-functional team approaches in smaller companies were less formal than larger companies if the development team was in-house. When smaller companies involved other firms with the project development then the approach had to become more formal.

Other differences in the nature of multi-functional team approaches adopted in companies of different sizes were discussed in Section 6.2. Particularly in small companies, the concept of multi-functionality tended to mean multi-tasking in different areas of expertise since all team members were not experts in every area. Furthermore, in the small company, the co-ordination of multi-functional teams tended to be managed by the same person throughout the development process. By contrast, in medium and large-sized companies there was no clear trend and sometimes the project was co-ordinated by the same person throughout the innovation process and sometimes staff representing different functional backgrounds took over the co-ordination function at different phases. The small firm trend could be explained by the tendency for smaller companies to own scarce human resources. Team co-ordinators in the smaller companies operated multi-functionally in order to address the pressures of innovating in a small business context. This was clearly a source of satisfaction for team members who could work in new areas and follow the whole innovative development process through.

By contrast multi-functional team approaches in the larger companies, tended to involve expert team membership. In the case of Analytik, multi-tasking was discouraged as a barrier to inter-functional integration. A multi-functional team approach in this company did not imply the idea of individual staff multi-tasking outside their own functional area but the concept of functional experts teamworking with other experts. This suggested that in the smaller company the multi-functional team and its effectiveness was more likely to reflect the extensiveness of members' competency, whereas in the larger company the multi-functional team reflected the organisational structure and the contribution of expertise from departments to the multi-functional team.

Two small companies (R&D Laboratories and Systems Engineering), one large company (Longman Engineering) and one medium-sized company (Datalog) adopted single-disciplinary team approaches. With so few companies to draw from, it is speculative to compare the single-disciplinary approaches between companies of different sizes. When projects were client-funded they were not limited by this single-disciplinary approach. However, the approach was clearly limited for projects directed at open markets. For example, in R&D Laboratories the contribution of additional marketing and manufacturing expertise was sought from a large company which failed to deliver the expected business functions and left R&D Laboratories in a vulnerable market position with the threat of liquidation. In Datalog, a weak and marginal marketing function almost led to the loss of a



significant selling opportunity and may have contributed to project problems and low profits. Generally, projects developed by single-disciplinary teams that were not client-funded required additional expertise from other companies for the commercialisation of the innovative idea. The absence of in-house business expertise brought a greater dependency in the relationship between the partners, which left the small firm particularly in a vulnerable position.

Multi-disciplinary team approaches were adopted by companies of all sizes, although predominantly by large companies. Such approaches were adopted for either client-led contracts or for projects intended to benefit internal operations. Firm size did not appear to differentiate the multi-disciplinary teams in the sample. In this sample, multi-disciplinary team approaches may be appropriate to the development of client-funded innovative products and processes in companies of all sizes because there was an availability of in-house expertise and little financial risk-taking for the companies. In other words, the company's resources was not a factor influencing the appropriateness of multi-disciplinary teams to companies of different size.

Although variations in the team approaches adopted by companies of different sizes did not appear significant, one difference was the small company's multi-functional team approach which was more informal and involved more multi-tasking.

### ***7.3. Associations Between Level Of Project Innovation And Team Approaches***

Section 7.3.1. analyses the implications of innovative project developments for organisational approaches to innovation in general. Furthermore Sections 7.3.2., 7.3.3. and 7.3.4. discuss the associations between the level of project innovation of a project and the type of team approach adopted, drawing on both intra-company and inter-company analysis of company cases.

#### **7.3.1. Level Of Project Innovation And Requirements For New Organisational Structures**

The development of innovative products and processes often required or led to other structural changes in addition to the establishment of team approaches. These changes included inter-company collaborations, new company formations and the use of teams. The relationship between the level of project innovation and organisational approaches to developing innovative products and processes is presented in Table 7.2. All of the 28

projects considered in this research involved liaisons of some kind with other companies which included:

- establishing development partnerships;
- setting up development testing arrangements;
- sub-contracting project development work including manufacturing, development testing and design work;
- working closely with clients in either client-funded projects or projects targeted at interested clients.

**Table 7.2. New Organisational Approaches For Projects Of Varying Innovation**

Note: Projects were classified according to a scale which differentiated major from minor innovations during the interview (See Appendix 2; Chapter 4).

Note: categories are not exclusive

New Organisational Approaches For Developing Innovative Products/Processes	Minor Innovation and Design Variants	Major Innovation	Total
Formation of new company as a result of project	R&D Laboratories, New Carbon Ventures, Powerengineering, Greenwater	Biogentech, Cheminstrum	6 projects
Liaison with other companies	All projects	All projects	28 projects
Development partnership	Engineering Projects, Robinson Engineering, Datalog, R&D Laboratories, CWT Engineering, New Carbon Ventures, Water Services, Powerengineering, Longman Engineering (1)	Sensorval, Biogentech	11 projects
Development testing arrangement	Effluent Treatment Systems, Robinson Engineering, Powerengineering	Analytik(2)	4 projects
Sub-contraction of project work	Wasserpur, EMS, Effluent Treatment Systems, Robinson Engineering, Innovconsult, Biogentech, EMS, Water Quality Utilities	Cheminstrum	9 projects
Liaison with client	Pollution Control Engineering, Effluent Treatment Systems, Systems Engineering, Wasserpur, EMS, Engineering Projects, Robinson Engineering, Longman Engineering (1,2), Sludge Treatment Systems, Filtratec (1), Innovconsult, Powerengineering Technologies, CWT Engineering, Innovconsult	Biogentech	16 projects
Non-continuous collaborations	Gulls Exports	Wind Power Projects	2 projects

### 7.3.2. Inter-Company Analysis

Beginning with an inter-company analysis, Table 7.3 presents an appraisal of the level of technological project innovation in relation to the different approaches taken to the co-



ordination of innovation developments. It may be significant that five of the six most innovative projects were developed using multi-functional teams. The exception was Wind Power Projects, a non-team approach to the development of a waste water treatment project. It was interesting that four of these companies were small firms, thereby suggesting associations between the level of project innovation, the adoption of multi-functional team approaches and the small company; only one large company was involved with a major innovation development. However, multi-functional teams were also adopted for minor innovations which showed that this type of approach was also applicable to the development of more minor innovations. Further research on a bigger sample would test statistically for the significance of these relationships. The results are in keeping with the literature reviewed in Chapter 2 which found that multi-functional team approaches were valuable for developing projects of varying levels of innovation (See Section 2.3).

Although multi-functional team approaches were adopted by companies involved with projects of varying levels of innovation, the findings suggested that the majority of major innovations were developed using multi-functional teams. The multi-functional teams tended to integrate smaller teams, either multi-disciplinary or single-disciplinary, from the companies involved with the development work. The integration of sub-teams with the co-ordination of multi-functional teams may be because the development of more innovative products and processes requires a more dedicated R&D effort.

Comparisons between company approaches to developing innovative products and processes showed that major innovative projects unlike minor innovations were typically co-ordinated by a technical manager who multi-tasked, in several different areas of scientific, technological, technical or business expertise, to develop products for unestablished markets where technologies needed to be proven. This was true of Analytik (project 2), Biogentech, Cheminstrum, Wind Power Projects and Sensorval.

**Sensorval**

The R&D Director co-ordinated the development of a water pollution detection project and integrated expertise in chemical testing with micro-processing technology and sensor technology. She derived the new product ideas from her awareness of the literature on scientific and technological developments. She explained that 'there comes a point in R&D when you have to think about the next generation of products...because we have just about developed all the products we know there is a market for'. The intention was that this innovative work would provide Sensorval with its next generation of products in newly created environment markets.

Table 7.3. Association Between Innovation, Companies And Teams

Adapted from ideas presented in Table 4.2.

Abbreviations:

*MFT is a Multi-functional team*

*SDT is a Single-disciplinary team*

*MDT is a Multi-disciplinary team*

Level of Innovation	Company	Team approaches
Radical breakthrough -undertakes an entirely new function and extends the state of the art		0
Major company product/process innovation - a major technical shift involving the development or application of new technologies	Analytik (2), Filtratec (2), Cheminstrum, Biogentech, Sensorval, Wind Power Technologies	Total=6 projects 5 MFT 1 solo non-team
Minor product/process innovation - involves incremental changes to develop existing or new products/processes using or combining existing technologies	R&D Laboratories, Engineering Projects, Gulls Exports, Water Services, Analytik (1), Filtratec (1) Wasserpur, Datalog, Effluent Treatment Systems, Pollution Control Engineering, New Carbon Ventures, Sludge Treatment Systems, Robinson Engineering, Powerengineering, CWT Engineering, EMS, Longman Engineering (1&2), Innovconsult, Water Quality Utilities	Total= 20 projects  6 MFT 3 SDT 8 MDT 2 solo non-team 1 multi-disciplinary group
Design variants and new models -redesigns or imitations	Systems Engineering Greenwater	Total =2 projects  1 SDT 1 MFT
Old/traditional - either a very slight or zero change		Total = 0 projects

### 7.3.3. Intra-Company Differences

Moving on to an intra-company analysis of the different approaches adopted to projects of varying levels of innovation, Table 7.4. shows that companies tended to develop more major innovations in a different way to more routine or minor innovations. However, information was only available in 9 companies for intra-company analysis of team approaches. Sixteen companies were omitted from the intra-company analysis in this section for the following reasons:

- Four companies - Biogentech, Greenwater, R&D Laboratories and Cheminstrum - had no other business apart from the innovative projects under discussion;



- Three companies - Pollution Control Engineering, Powerengineering, Systems Engineering - offered no information for comparison because the companies developed their innovative work as part of their main business projects;
- Nine companies - Wasserpur, EMS, Engineering Projects, Water Services, Water Quality Services, Gulls Exports, Effluent Treatment Systems, Datalog and Longman Engineering - presented no comparative information.

Table 7.4. Intra-Company Differences With Projects Of Varying Innovation

Abbreviations:

MFT indicates Multi-functional team

SDT indicates Single-disciplinary team

MDT indicates Multi-disciplinary team

Company	Approach to developing routine or less innovative products /processes	Approach to developing more innovative products/processes
Filtratec	MFT approach where members interacted continuously throughout the development of the client-led project	Varied perceptions but mainly a dedicated SDT team which was a MFT by virtue of its informal access to the organisational resources and expertise
Analytik	MFT approach with involvement from primarily one engineering discipline	MFT approach which was a longer process involving more experimentation and a greater involvement of disciplinary sub-teams
Sludge Treatment Systems	A formal departmental MDT approach where all staff resources were available within a department to a project manager working on client led projects	Less formalised MDT approach drawn from a matrix departmental structure
Robinson Engineering	An MDT mainly in-house task force drawn from different departments to tackle client-led projects	Several SDT & MDT teams drawn from different companies who at times operated sequentially, interactively and in parallel during the project development
CWT Engineering	A large MDT task- force drawn from different departments involving intense interaction with a client team	A small MDT team drawn from each of the companies involved with the development of a less lucrative and therefore lower priority project
Sensorval	MFT drawn from mainly one department in-house with access to departmental resources	MFT approach formed from several SDT's and MDT's from three companies with one project manager from Sensorval
Innovconsult	In-house MFT approach to carefully costed and planned client-funded projects which set up further teams from other companies including client company when appropriate	Identical MFT approach adopted for more innovative in-house R&D projects
New Carbon Ventures	Task-force or matrix in-house MDT team approach	Loose informal multi-disciplinary group from two companies
Wind Power Projects	MDT team approach using in-house expertise plus consultants	One person operation with some input from students and a failed attempt at inter-company collaboration
<b>Total=9 companies</b>	<b>5 MDT 4 MFT</b>	<b>2 non-team 4MFT 3MDT</b>

Table 7.3 has shown that comparisons of inter-company team approaches would imply little overall difference in the approach to projects of varying innovation. Intra-company



analysis showed that there are important differences in the approaches adopted to more versus less innovative project developments.

**7.3.3.1. Developing Innovative And Routine Projects**

Generally more innovative projects involved the co-ordination of more dedicated R&D team(s) whereas routine projects involved greater day-to-day interactions between disciplinary experts and business functional representatives. The members of multi-functional or multi-disciplinary teams were continuously involved when they worked on *routine business* projects, whereas interaction between members was discontinuous when more innovative products and processes were being developed.

Unlike routine projects, projects that were more innovative were often given a lower organisational priority and treated as a sideline. The cases of New Carbon Ventures and Wind Power Projects suggested that innovative projects may be given a lower priority as a result of their risky or long-term possibilities by comparison with secured, more urgent contract work. R&D was a side-line in CWT Engineering and was organised in a way which reflected this.

CWT Engineering

As a large construction company, CWT did not typically work on innovative projects but focused sales staff on winning design and construction contracts which were then developed by task-forces under project managers. When they secured a major construction contract with a long-term client, they were requested to develop an additional end-of-pipe waste treatment process because of environmental legislation which concerned the client. The main contract involved hundreds of staff working in teams on the project, sometimes together in the same office. In the context of this larger contract, the Senior Process Engineer described the development project as ‘really a very small tail on a very big dog’.

Working with the client, they set up a joint development agreement equally sharing the costs of the experimental work on the development project. By comparison with the hundreds of staff working on the main project, there was a maximum of eight staff from both companies working in the project team, bringing expertise of process engineering and industrial design, analytical chemistry, chemical and software engineering, mathematical modelling, production engineering, suppliers and the end user expertise to the core team.

Greater organisational interest and planning went into developing the more minor innovation than the more major innovation in CWT Engineering. That innovative work may be identified as too risky to be afforded a high organisational priority was also evident in several companies which integrated innovative work with their main business projects, including Pollution Control Engineering, Powerengineering and Systems Engineering.



### **Pollution Control Engineering (PCE)**

PCE only innovated as a result of their client's progressive interest in contracting an effluent treatment process which was an advance on what was legally required by environmental regulations. This was an unusual situation but the Project Manager explained 'People are realising that if you are going to invest a lot of money in a project, why not invest a little more and perhaps meet regulations a few years hence, rather than have to rip out or face major purchases again in the future'.

Innovation as a sideline and low organisational priority was also evident with Sludge Treatment Systems which capitalised on earlier innovative work in contracts where incremental changes were made. This was also true for both Gulls Exports and Effluent Treatment Systems which only conducted innovative work when they were not too pressed by other business pressures. Furthermore, R&D appeared to be a side-line in Robinson Engineering to the extent that the Technology Development Manager was more likely to liaise with external organisations than with internal departments. Innovconsult was another case where in-house funded R&D projects were a side-line or rarity because it was difficult to find the time for busy staff to work on non-client-funded R&D projects.

#### ***7.3.3.2. Developing Major And Minor Innovations***

There was comparative information on the different ways that companies approach major and minor innovations available in only three cases, Analytik, Sensorval and Filtratec. These companies all adopted multi-functional team approaches to developing their more major innovative products and processes. The multi-functional teams associated with major innovation developments, involved either the co-ordination of several teams or the occasional integration of representatives of business functions into what was essentially a development team.

The cases of Analytik and Sensorval suggested that developing more major innovative products and processes required a greater recruitment of disciplinary or business functional expertise. In the case of Sensorval this required inter-company collaborations because the company neither wished to nor could recruit the necessary expertise from within the company.

## Sensorval

Sensorval was organised along departmental lines but had some elements of an organic structure since 'everyone gets involved' with project developments in their area of environmental monitoring instrumentation. Typically sales and marketing were involved in the initial product specification. The Managing Director had the ultimate say on any developments and the finance department provided advice on the legal ramifications of company operations. Until 2 years ago, Sensorval did all the R&D work in-house, using a multi-disciplinary team of graduate chemists, the R&D Director and a part-time production person. Following the specification of the market, the in-house development projects involved the several steps to develop chemical environment tests. These were:

- Identify a test method;
- Evaluate the methods available;
- Develop the test by looking for interference's (which might make the test unreliable) and the best reaction conditions (in terms of temperature and time parameters);
- Packaging;
- Quality control of product by checking impacts of production, the short and long term stability and raw materials prior to use;
- Document the following procedures: quality management, the rationale for product development methodology, the product manufacturing methodology and the product profile in terms of functionality, purpose and quality control.

The R&D Director pointed out that 'each one of these stages is a test and not just a hurdle to get past, so at any stage the product may fail and you might go back to the beginning'. This implied that these stages if tackled successfully might take only 3 months, though they could take 'forever', although generally it was a predictable development process.

More recently they became involved in developing more innovative products which integrated their in-house expertise in chemical testing with technological expertise supplied by other companies in the areas of micro-processing and sensor technologies. The more innovative collaborative project, required the usual in-house development steps with additional steps. The additional phases of product development included:

- Liaison with collaborating companies contributing different areas of technological expertise;
- Production of instrument prototype and pilot batches of electrodes in collaborating companies;
- Testing for validation including comparison with other methods, testing for interferences and 'real-world' applications using multi-user trials, instrument trials and idiot tests.



*Continued.*

There were other differences in the project management, such as a greater emphasis on quality control and the requirement for the design of a quality specification. There were some differences in the sales and marketing role for the more innovative product developments, such as promotion at scientific conferences and in the press. The R&D Director contrasted her experience of managing in-house projects with this more innovative collaborative project. She pointed out that there were greater project management and planning difficulties because with a more innovative project, you cannot know about potential problems and if you could, you would not be inventing anything new. The less innovative projects were more predictable, controllable and desirable. She said 'The internal product management is a very well-defined type of product. I know what the next stage is and we don't usually have too many surprises'.

As with Sensorval, the case of Analytik supported the view that more major innovations require a greater recruitment of multi-disciplinary or business functional expertise. Analytik was involved with the development of two sensor projects for environmental monitoring purposes, but the more major innovation of the two projects required a greater input of multi-disciplinary expertise. Unlike Sensorval, this expertise was mainly drawn from within the company.

#### **Analytik**

The more innovative sensor project (2) was at the initial stages of development at the time of the interview, unlike the less innovative project which had already been launched. Although the team approaches to each project development were multi-functional, the team membership of the more innovative project team integrated more disciplinary expertise, including mechanical, software and electrical engineering, chemistry, physics and industrial design. Once patent protection was secured, they involved external parties for both the testing of the sensor and for purchasing new manufacturing machinery. The core team had a strong scientific and engineering base whereas the less innovative project team had engineering expertise but did not require scientific expertise.

The importance of a multi-disciplinary approach to developing innovative products and processes was expressed by the Managing Director of Biogentech who said 'People become blinkered. The real inventions tend to come out of collaborations. If you think in a channel you will only ever come up with something which fits into a channel. If you are sitting next to someone who thinks in a different channel, then what one says to the other initially might seem ridiculous, but they may think - well maybe not - and it is a snap process; one person's crazy idea about some-one else's area'.

Filtratec was the third company for which there was comparative information available on intra-company approaches to developing projects of varying innovation. Like Analytik and Sensorval, the more innovative project development was not a sideline but a high priority,



market-led project. In Filtratec, this was probably a result of the potential attributed to the project which was alleged to be a revolutionary project which would 'stand the market on its head'.

#### **Filtratec**

The less innovative project (1) required a simple adaptation of in-house technology for a client-funded water purification product development project. There was a multi-functional team approach to this project which included expertise in chemistry, industrial design and chemical, mechanical and software engineering. The more major innovative project aimed to improve industrial effluent treatment by advancing membrane technology. It had had a core team of three staff representing marketing, chemistry and chemical engineering, although the marketing staff were chiefly involved with the product definition.

Like the other cases of major innovations in companies, Filtratec supported the importance of dedicated R&D teams which at times needed to work separately during project development from team members not involved with the development work.

### **7.4 Summary**

In the small firm, the multi-functional team approach was less formal unless involved with inter-company collaborations and usually team members multi-tasked in areas where they both had and lacked expertise. By contrast, medium and large-sized firms tended to involve expert members who strayed less from their area of competence. Furthermore, the co-ordination of innovation developments tended to be managed by the same person in the small firm by contrast with medium and large firms where there was considerable inter-firm variation in terms of which functional representative co-ordinated different phases of the innovation process.

Inter-company and intra-company analysis supported the assertion that companies approached the development of more innovative products and processes differently from less innovative or routine projects. Irrespective of how innovation was approached, more technologically innovative projects tended to require new organisational arrangements, including teams, inter-company liaisons or new business formations. This supported Rothwell's identification of different types of innovation, such as organisational innovation and supports the association of organisational innovation with the development of technological innovations (Rothwell, 1992).



Although the level of innovation did not appear to differentiate multi-functional team use by companies, there was variation in the nature of the multi-functional team approach adopted. More innovative projects were often associated with:

- inter-company alliances;
- the involvement of more areas of disciplinary expertise;
- more teams, including those with a strong R&D orientation;
- a technological project leadership which often reflected multi-disciplinary expertise particularly when markets were unestablished <sup>1</sup>;
- less continuous involvement of project associates throughout the project development;
- a lower organisational priority in terms of resourcing, particularly if projects were far from market.

There were noteworthy differences between the multi-functional team approaches adopted for routine projects versus minor and major innovation projects: routine projects tended to involve a single team with a continuous membership, whereas minor and major innovations tended either to involve the co-ordination of several teams integrated within a team approach or the drafting in of relevant functional expertise when appropriate to the core development team. Major innovation project teams were characterised by a more multi-disciplinary membership including more areas of scientific, engineering or technological expertise. Furthermore, major innovations required the establishment of dedicated R&D teams that were typically integrated within a multi-functional team approach.

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<sup>1</sup> For example, technical staff in the companies Biogentech, Filtratec, Wind Power Projects, Cheminstrum and Sensorval all identified the market potential for major innovations.

# Chapter 8 Evaluation Of Team Effectiveness

## ***8.1. Introduction***

Chapter 2 argued that it can be difficult to achieve team effectiveness since group processes are influenced by several interrelated factors which have complex impacts on effectiveness. This suggests that any team approach, including multi-functional team approaches, are unlikely to be an absolute panacea for management problems in innovation. This chapter evaluates the effectiveness of the team approaches adopted by companies involved with innovative project developments.

Section 8.2 presents an overview of team operations, both positive and negative aspects, as perceived by the members of teams. Section 8.3. presents the problematic aspects of team operations and considers whether there are differences in the tendency of single-disciplinary, multi-disciplinary or multi-functional team approaches to experience problems in team operations. Section 8.4. presents the positive aspects of team operations as well as areas where company learning occurred in team operations and considers whether there are differences in the tendency of single-disciplinary, multi-disciplinary or multi-functional team approaches to learn or experience positive aspects in team operations. Section 8.5. explores team member perceptions of team effectiveness and satisfaction and whether specific types of teams were more likely to be perceived as effective and satisfactory than others. Furthermore, consideration is given of the positive and negative aspects of team operations which differentiate effective from less effective teams and satisfactory and from less satisfactory teams. Finally, 8.6 evaluates case studies which provide an insight into whether multi-functional teams deliver the intended benefits associated with them. Drawing on the case studies, some ideas on best practice in team management are also presented.

## ***8.2. Team Operations***

To provide a basis for analysis in this chapter, we developed a checklist of important team characteristics which were identified in Chapter 2 from an analysis of group theories and team models. This included a set of team characteristics, classified as team membership, interaction, task and external relationships. Using information gathered from interviews and questionnaires, the team operations of multi-functional, multi-disciplinary and single-disciplinary teams were rated as positive when there was evidence of good practice and



team learning, or negative when there was evidence of problems, in Tables 8.1-3. Tables 8.1-3 allow the quantification of problems, good team practice and team learning in terms of different aspects of team operations. This provides a basis for exploring team operations, identifying team problems and good practice as well as comparing the different team approaches.

Table 8.1. Multi-Functional Team Operations

Abbreviations:

*+ indicates a positive aspect:*

*X indicates a negative aspect*

*L indicates that learning took place*

NB. company names are abbreviated

Areas of Team Operations	Engin. Project	EMS	Wasser.	Analyt. (1)	Analyt. (2)	Innov-consult.	Sens orval
<b>Membership</b>							
Size		X	+	X			
Employment stability of project staff		X	+				
Expertise		X	+	+	+	+	
Motivation and initiative			X	X		+	X
<b>Team Interaction</b>							
Member compatibility	X	X	X	X		+	
Compatibility between different functional representatives	X	X	+	+	+	+	
Leadership & project championing	X		X			+	XL+
Co-ordination of team	X	X	X				XL+
Team spirit, co-operation, trust and cohesiveness	X	X	X	X		+	X
Communication	+	+	X	X		+	XL+
<b>Task</b>							
Goal directedness			X	X			
Project planning and organisation		XL	XL	XL	+L	+L	XL+
Clarity of procedures		+	X	X			XL
Meeting set objectives	X	X	X	X		+	X
Conflicting work demands		X	X	X			
Division of labour & responsibility		X	X				X
<b>External Relationships</b>							
In-house relationships	X	X		XL	L		
Organisational support-culture or resourcing			XL	XL	L	X+	
Inter-company relationships			X			+	XL+
<b>Total problems</b>	7	12	14	12	0	1	10
<b>Total positive and learning aspects</b>	1	3	6	5	6	12	11

Table 8.1. *Continued.*

Areas of Team Operations	Biog.	Chem	Green	Filtrat (1)	Filtrat (2)	Long (2)	Total (X)	Total (+&L)
<b>Membership Size</b>		X+	X	X	X		6X	2+
Employment stability of project staff	X					X	3X	1+
Expertise	X	X+	X				4X	5+
Motivation and initiative	X		+				4X	2+
<b>Team interaction</b>								
Member compatibility							4X	1+
Compatibility between different functional representatives							2X	4+
Leadership & project championing				X	X		5X	2+1L
Co-ordination of team	X						5X	1+1L
Team spirit, co-operation, trust and cohesiveness			+			X	6X	2+
Communication							3X	4+1L
<b>Task</b>								
Goal directedness			+				2X	1+
Project planning and organisation	XL+	+L					5X	5+8L
Clarity of procedures	XL+	X					5X	2+2L
Meeting set objectives			+				5X	2+
Conflicting work demands							3X	
Division of labour & responsibility		X		X	X	X	7X	
<b>External Relationships</b>								
In-house relationships				X	X		5X	2L
Organisational support-culture or resourcing		X		X	X	X	7X	1+3L
Inter-company relationships	XL+	X					4X	3+2L
<b>Total problems</b>	7	6	2	5	5	4	85	
<b>Total positive and learning aspects</b>	6	4	4	0	0	0		58



Table 8.2. Single-Disciplinary Team Operations

Abbreviations:

+ indicates a positive aspect:

X indicates negative aspect:

L indicates learning took place

NB company names are abbreviated

Areas of Team Operations	Datalog	R&D Labs	Longman Eng.(1)	Systems Eng.	Total (X)	Total (+&L)
<b>Membership</b>						
Size					0	0
Stability of project staff	X	X	X		3X	0
Expertise	X	X			2X	0
Motivation and initiative	+				0	1+
<b>Team Interaction</b>						
Member compatibility	+			+	0	2+
Leadership & project championing	+	+			0	2+
Co-ordination of teams			X		1X	0
Team spirit, co-operation, trust and cohesiveness	+		X		1X	1+
Communication				+	0	1+
<b>Task</b>						
Goal directedness					0	0
Project planning and organisation		+	XL+		1X	2+1L
Clarity of procedures					0	0
Meeting set objectives	X	X	X	X	4X	0
Conflicting work demands	X				1X	0
Division of labour & responsibility			X		1X	0
<b>External Relationships</b>						
In-house relationships between different functional groups	XL				1X	1L
Organisational support-culture or resourcing	XL	X	XL		3X	2L
Inter-company relationships	XL	X	X	X	4X1L	4X1L
<b>Total problems</b>	7	5	8	2	22	0
<b>Total positive and learning aspects</b>	7	2	3	2	0	14

Table 8.3. Multi-Disciplinary Team Operations

Abbreviations:

+ indicates a positive aspect:

X indicates negative aspect:

L indicates learning took place

NB company names are abbreviated

Areas of Team Operations	Robinson Eng.	Pollution Control.	Water Serv.	CWT Eng.	Water Qual.	Sludge Treat.	Power Eng.	Total (X)	Total (+&L)
<b>Membership</b>									
Size	X	X	X	+		X	X	5X	1+
Stability of project staff	X		X	+			X	3X	1+
Expertise	X	+	X+L	+		+		2X	4+1L
Motivation and initiative			+					0	1+
<b>Team Interaction</b>									
Member compatibility		+	X+	+	+		+	1X	4+
Compatibility between different functional representatives	X		X+	+		+		2X	3+
Leadership & project championing	+	+	X+				+	1X	4+
Co-ordination of teams		+	X		X			2X	1+
Team spirit, co-operation, trust and cohesiveness	X	+	X	+	+			2X	3+
Communication		+						0	1+
<b>Task</b>									
Goal directedness	+	+	X					1X	2+
Project planning and organisation		+				+		0	2+
Clarity of procedures								0	0
Meeting set objectives			X	+				1X	1+
Conflicting work demands	X						X	2X	0
Division of labour & responsibility	X	X					X	3X	0
<b>External Relationships</b>									
In-house relationships					X	X	X	3X	0
Organisational support-culture or resourcing	X	X	X	X+	X	X	X	7X	1+
Inter-company relationships	XL	+	XL	+		X		3X	2+2L
<b>Total problems</b>	9	3	12	1	3	4	6	38	
<b>Total positive and learning aspects</b>	3	9	7	9	2	3	2		35

### 8.3. Associations Between Team Approaches And Team Problems

Positive aspects of team operations were mentioned less often than team problems. This section outlines the team problems experienced by 13 multi-functional project teams, 4 single-disciplinary project teams and 7 multi-disciplinary teams. Comments made by every participant team member were taken into consideration and frequently there were different perceptions of team problems within teams. This is exemplified in the case of Wasserpur where there was response from four managers associated with the project team.



### **Different Perceptions Of Team Problems**

In Wasserpur, each team respondent mentioned different problems, varying in importance, which affected team effectiveness in developing a water purification product. From the Marketing Director's perspective, these problems included poor resources of time, staff and money for the project which led to the staff being over-stressed and overworked. The other team respondents mentioned weak leadership, unclear goals and briefing, unclear procedures for operations, poor communication within the team, uncooperative members, unfair work loads, over-stressed and overworked staff, poor sharing of responsibilities, low acceptance of accountability for results, poor resources for operations and poor organisational rewards for team work.

Despite these criticisms three out of the four respondents regarded the team as effective and were satisfied with the experience of working as part of a team as well as the project results. Although one respondent was dissatisfied with the experience of working as part of a team and appraised the team as ineffective, all respondents were willing to work together again. However, as the Project Manager said 'it is a case of maybe having to, as opposed to wanting to, work together with some of the people that were involved'.

It was evident that the experience of working in a team hadn't been entirely satisfactory and that many problems were problems with people. The most dissatisfied team respondent thought that there was minimal input from management and other team members. He thought that the main contribution to the project came from a couple of competent engineers and consequently he did not feel that 'the approach taken was fully one of being a team'. By contrast, the Project Manager thought the company has benefited from having a team involved. He hoped and expected that the rest of the team would feel very satisfied with the technical and commercial results, because despite the problems within the team, the multi-functional team approach had a strong influence on the technical performance of the product and its commercial success.

Table 8.4. presents the frequency with which team problems were associated with different team approaches.

The five most common team problems in respective order of frequency were: with organisational resourcing and support, inter-company relationships, the division of labour and responsibility, meeting set objectives and small team size. Table 8.4 shows that the greatest number of problems were experienced by:

- multi-functional teams in the area of task management and planning;
- single-disciplinary teams and multi-disciplinary teams in the area of managing external in-house or inter-team relationships.

Table 8.4. Problems Of Multi-Functional Teams, Single-Disciplinary Teams And Multi-Disciplinary Teams

NB. Percentages are given for problems associated with different team approaches

Problems in Team Operations	Multi-Functional Teams	Single-Disciplinary Teams	Multi-Disciplinary Teams.	Total
<b>Membership</b>				
Size	6		5	11
Stability of project staff	3	3	3	9
Expertise	4	2	2	8
Motivation and initiative	4			4
<b>Total Membership</b>	<b>17 (20%)</b>	<b>5 (23%)</b>	<b>10 (26%)</b>	<b>32</b>
<b>Team Interaction</b>				
Member compatibility	4		1	5
Compatibility between different functional representatives	2		2	4
Leadership & project championing	5		1	6
Co-ordination of teams	5	1	2	8
Team spirit, co-operation, trust and cohesiveness	6	1	2	9
Communication	3			3
<b>Total Team Interaction</b>	<b>25 (29%)</b>	<b>2 (9%)</b>	<b>8 (21%)</b>	<b>36</b>
<b>Task Management &amp; Planning</b>				
Goal directedness	2		1	3
Project planning and organisation	5	1		6
Clarity of procedures	5			5
Meeting set objectives	5	4	1	10
Conflicting work demands	3	1	2	6
Division of labour & responsibility	7	1	3	11
<b>Total Task Management &amp; Planning</b>	<b>27 (32%)</b>	<b>7 (32%)</b>	<b>7 (18%)</b>	<b>41</b>
<b>External Relationships</b>				
In-house relationships	5	1	3	9
Organisational support-culture or resourcing	7	3	7	17
Inter-company relationships	4	4	3	11
<b>Total External relationships</b>	<b>16 (19%)</b>	<b>8 (36%)</b>	<b>13(34%)</b>	<b>37</b>
<b>Total Team Problems</b>	<b>85 (100%)</b>	<b>22 (100%)</b>	<b>38 (100%)</b>	<b>145</b>
<b>N</b>	<b>13</b>	<b>4</b>	<b>7</b>	<b>24</b>

The fewest problems were experienced by:

- multi-functional teams in the area of managing external in-house or inter-team relationships;
- multi-disciplinary teams in the area of task management and planning;
- single-disciplinary teams in the area of team interaction.



**8.3.1. Significant Differences In The Problems Of Teams**

Were there any differences between multi-functional teams, multi-disciplinary teams and single-disciplinary teams in terms of the distribution of problems experienced in team operations?

Table 8.5 Problems In Team Operations By Team Type

NB. Information given is the sum of problems associated with each project team drawn from Tables 8.1, 8.2. and 8.3.

Company Team	Multi-Functional Teams	Single-Disciplinary Teams	Multi-Disciplinary Teams
1	7	7	9
2	12	5	3
3	14	8	12
4	12	2	1
5	0		3
6	1		4
7	10		6
8	7		
9	6		
10	2		
11	5		
12	5		
13	4		
Total Team Problems	85	22	38
N	N=13	N=4	N=7

Using the Mann-Whitney test of differences we tested for differences between team approaches in terms of the experience of problems in areas of team operations - team membership, interaction, task and external relationships - with the following results:

**Differences in the Team Problems of Multi-Functional Teams and Single-Disciplinary Teams**

W = 119.5

The test is only significant at 0.8196 (adjusted for ties) which is not-significant at the 0.05 level.

Result is non-significant, i.e. there is no significant difference between multi-functional teams and single-disciplinary teams in the distribution of team problems.

**Differences in the Team Problems of Multi-functional Teams and Multi-Disciplinary Teams**

W = 144.5

The test is only significant at 0.5508 (adjusted for ties) which is not-significant at the 0.05 level.

Result is non-significant, i.e. there is no significant difference between multi-functional teams and multi-disciplinary teams in the distribution of team problems.

### **Differences in the Team Problems of Multi-Disciplinary and Single-Disciplinary Teams**

$W = 25.0$

The test is only significant at 0.9245 (adjusted for ties) which is not-significant at the 0.05 level.

Result is non-significant, i.e. there is no significant difference between single-disciplinary teams and multi-disciplinary teams in the distribution of team problems.

The Mann-Whitney test showed that the differences between multi-functional teams, single-disciplinary teams and multi-disciplinary teams of problems in team operations were not significant at the 0.05 level of significance.

### ***8.4. Positive Aspects Of Team Operations***

Table 8.6. presents the frequency with which different team approaches were associated with positive aspects of team operations.

The five most common positive aspects of team operations in respective order were: project planning and organisation, inter-company relationships, expertise, leadership and member competency.

Table 8.6. shows that the greatest number of positive aspects of team operations were experienced by:

- multi-functional teams in the area of task management and planning (which was also the area where greatest problems were experienced);
- single-disciplinary and multi-disciplinary teams in the area of team interaction.



Table 8.6. Positive Aspects Of Multi-Functional Teams, Multi-Disciplinary Teams And Single-Disciplinary Teams

NB. Evidence of learning in areas of team operations are bracketed and added to areas of positive team operations

Positive Aspects of Team Operations	Multi-Functional Teams	Single-Disciplinary Teams	Multi-Disciplinary teams.	Total
<b>Membership Size</b>	2		1	3
Stability of project staff	1		1	2
Expertise	5		4 (+1)	10
Motivation and initiative	2	1	1	4
<b>Total Membership</b>	<b>10 (17%)</b>	<b>1 (7%)</b>	<b>8 (23%)</b>	<b>19</b>
<b>Team Interaction</b>				
Member compatibility	1	2	5	8
Compatibility between different functional representatives	4		3	7
Leadership & project championing	2(+1)	2	4	9
Co-ordination of teams	1(+1)		1	3
Team spirit, co-operation, trust and cohesiveness	2	1	3	6
Communication	4(+1)	1	1	7
<b>Total Team Interaction</b>	<b>17 (29%)</b>	<b>6 (43%)</b>	<b>17 (49%)</b>	<b>40</b>
<b>Task Management &amp; Planning</b>				
Goal directedness	1		2	3
Project planning and organisation	5(+8)	2(+1)	2	18
Clarity of procedures	2(+2)			4
Meeting set objectives	2		1	3
Conflicting work demands				
Division of labour & responsibility				
<b>Total Task Management &amp; Planning</b>	<b>20 (34%)</b>	<b>3 (21%)</b>	<b>5 (14%)</b>	<b>28</b>
<b>External Relationships</b>				
In-house relationships	(+2)	(+1)		3
Organisational support-culture or resourcing	1(+3)	(+2)	1	7
Inter-company relationships	3(+2)	(+1)	2(+2)	10
<b>Total External relationships</b>	<b>11 (19%)</b>	<b>4 (29%)</b>	<b>5 (14%)</b>	<b>20</b>
<b>Total Positive &amp; Learning Aspects</b>	<b>58 (100%)</b>	<b>14 (100%)</b>	<b>35 (100%)</b>	<b>107</b>
<b>N</b>	<b>13</b>	<b>4</b>	<b>7</b>	<b>24</b>

#### 8.4.1. Significant Differences In The Positive Aspects Of Teams

Were there any differences between multi-functional teams, multi-disciplinary teams and single-disciplinary teams in terms of the positive aspects of team operations?

Table 8.7. Positive Team Operations By Team Approach

NB. Information given is the sum of the positive and learning aspects of each project team's operations drawn from Tables 8.1, 8.2. and 8.3.

Company Teams	Multi-Functional Teams	Single-Disciplinary Teams	Multi-Disciplinary Teams
1	1	7	3
2	3	2	9
3	6	3	7
4	5	2	9
5	6		2
6	12		3
7	11		2
8	6		
9	4		
10	4		
11	0		
12	0		
13	0		
<b>Total Positive Team Operations</b>	58	14	35
<b>Number of Teams</b>	N=13	N=4	N=7

Using the Mann-Whitney test we tested for significant differences between team approaches in terms of the experience of positive team operations by analysing areas of team operations - team membership, interaction, task and external relationships - with the following results:

**Differences in positive team operations of multi-functional teams and single-disciplinary teams**

$W = 242.5$

The test is only significant at 0.7474 (adjusted for ties) which is not-significant at 0.05 level.

Result is non-significant, i.e. there is no significant difference between multi-functional teams and single-disciplinary teams in the distribution of positive team operations.

**Differences in positive team operations of multi-functional teams and multi-disciplinary teams**

$W = 132.0$

The test is only significant at 0.7499 (adjusted for ties) which is not-significant at the 0.05 level.



Result is non-significant, i.e. there is no significant difference between multi-functional teams and multi-disciplinary teams in the distribution of positive team operations.

#### **Differences in positive aspects of team operations between single-disciplinary teams and multi-disciplinary teams**

$W = 19.5$

The test is significant at 0.4324 (adjusted for ties) which is not-significant at the 0.05 level.

Result is non-significant, i.e. there is no significant difference between single-disciplinary teams and multi-disciplinary teams in the distribution of positive team operations.

The Mann-Whitney test showed that the differences in the positive aspects of team operations between multi-functional teams, multi-disciplinary teams and single-disciplinary teams were not significant at the 0.05 level of significance.

### ***8.5. Effectiveness And Satisfaction With Team Operations***

This Section examines team perceptions of satisfaction and effectiveness. The sample was too small to test for significant differences between team approaches - multi-functional, multi-disciplinary and single-disciplinary - and perceptions of effectiveness and satisfaction. However, it was possible to statistically test whether perceptions of effectiveness were associated with the team operations of different team approaches, both positive and negative team operations. Furthermore, it was possible to test the significance of the relationship between team member perceptions of satisfaction and effectiveness.

#### **8.5.1. Team Member Perceptions Of Satisfaction**

Team members rated their satisfaction with both the team and the project outcomes and this information is presented in Tables 8.8.

Were there differences in the satisfaction of team members from multi-functional, multi-disciplinary and single-disciplinary team approaches? Table 8.8. suggests that satisfaction with team work and project results was more common than dissatisfaction in both multi-functional and multi-disciplinary team approaches. Interestingly, all multi-disciplinary teams were regarded as satisfactory, whereas there were mixed levels of satisfaction associated with both single-disciplinary and multi-functional teams. Although the sample was too small to allow for testing significant differences in the satisfaction of multi-

functional, multi-disciplinary and single-disciplinary teams, the results appear non-significant.

Table 8.8. Satisfaction Associated With Different Team Approaches

NB Teams were rated as satisfactory when members regarded them as giving at least average satisfaction. Team's were rated as unsatisfactory when at least one team member was dissatisfied.

Satisfaction	Multi-Functional Teams	Single-Disciplinary Teams	Multi-Disciplinary Teams
Satisfied Teams			
	Cheminstrum	Systems Engineering	Robinson Engineering
	Biogentech	Longman Engineering (1)	Pollution Control Engineering
	Filtratec (1&2)		Water Services
	Innovconsult		CWT Engineering
	Analytik (1&2)		Water Quality Utilities
	Sensorval		Powerengineering Technologies
	Greenwater		Sludge Treatment Systems
	Longman Engineering (2)		
Total project teams	10	2	7
Less Satisfied teams			
	Engineering Projects	Datalog	
	EMS	R&D Laboratories	
	Wasserpur		
Total project teams	3	2	0

### 8.5.2. Team Member Perceptions Of Effectiveness

Team members rated the effectiveness of the team and this information is presented in Table 8.9.

Table 8.9 Perceptions Of Team Effectiveness

NB. Teams were considered effective when they were rated as being at least average in effectiveness by all team respondents. Team effectiveness was regarded as 'mixed' when at least one team member described the team as ineffective.

Effectiveness	Multi-Functional Teams	Single-Disciplinary Teams	Multi-Disciplinary Teams
Effective Teams			
	Cheminstrum	Datalog	Robinson Engineering
	Filtratec (1&2)	Systems Engineering	Pollution Control Engineering
	Innovconsult	R&D Laboratories	Water Quality Utilities
	Greenwater		CWT Engineering
	Analytik (2)		Powerengineering Technologies
			Sludge Treatment Systems
Total effective project teams	6	3	6



Table 8.9. *Continued.*

Effectiveness	Multi-Functional Teams	Single-Disciplinary Teams	Multi-Disciplinary Teams
Mixed ratings of team effectiveness			
	Engineering Projects	Longman Engineering (1)	Water Services
	EMS		
	Wasserpur		
	Analytik (1)		
	Sensorval		
	Longman Engineering (2)		
	Biogentech		
Total teams given mixed ratings	7	1	1

Were there differences between multi-functional teams, single-disciplinary teams, multi-disciplinary teams in terms of their tendency to be rated as effective? Table 8.9. suggests that both single- and multi-disciplinary teams were more likely to be rated as effective than not. By contrast, multi-functional teams were more frequently given mixed ratings of effectiveness. By counting the problems and positive aspects of multi-functional, multi-disciplinary and single-disciplinary teams and relating this to ratings of team effectiveness, it was possible to conduct further statistical analysis. This contributes to an understanding of whether effective teams experienced fewer problems and more positive team operations than teams with mixed ratings of effectiveness.

**8.5.3. Team Effectiveness And Problems With Team Operations**

Table 8.10 quantifies the problems associated with each effective team and each team given a mixed rating of effectiveness, drawing information from Tables 8.1, 8.2, 8.3 and 8.9. Effective teams include all effective multi-functional, multi-disciplinary and single-disciplinary teams. Teams given mixed ratings of effectiveness include all appropriately rated multi-functional, multi-disciplinary and single-disciplinary teams.

Table 8.10 Comparison Of Team Problems Between Effective Teams And Teams With Mixed Ratings of Effectiveness

NB. Information given is the sum of problems associated with each project team drawn from Tables 8.1, 8.2 and 8.3.

Company Teams	Effective Teams	Teams With Mixed Ratings Of Effectiveness
1	1	7
2	6	12
3	2	14
4	0	12
5	5	10
6	5	7
7	7	4
8	5	8
9	2	12
10	9	
11	3	
12	1	
13	3	
14	4	
15	6	
Total Team Problems	59	86
Number of Teams	15	9

The Mann-Whitney Test Of Significant Differences in the problematic aspects of team operations shows that there were significant differences between effective teams and teams with mixed ratings of effectiveness in terms of team problems. Effective teams experienced significantly less problems in team operations associated with team membership, interaction, task and external relations.

$W = 131.5$

The test is significant at 0.0009 which is significant at the 0.05 level of significance.

Table 8.11. suggests that teams with mixed ratings of effectiveness experienced the greatest number of problems in the areas of team interaction and task management, whereas effective teams experienced the greatest number of problems in the area of external relationships, i.e. in-house or inter-company relationships.



Table 8.11. Problems Associated With Effective Teams And Teams With Mixed Ratings

Team Operations	Effective Teams	Teams with mixed ratings of effectiveness	Total
Team Membership	17 (29%)	15 (17%)	32
Team Interaction	5 (8%)	30 (35%)	35
Task Management & Planning	13 (22%)	28 (33%)	41
External Relationships	24 (41%)	13 (15%)	37
Total	59 (100%)	86 (100%)	145
N	15	9	24

**8.5.3.1. Problems Of Effective Multi-Functional Teams And Multi-Functional Teams With Mixed Ratings**

The sample was too small to test for differences in the team problems experienced within single-disciplinary teams and multi-disciplinary teams of varying effectiveness. However, it was possible to test multi-functional teams for the significance of differences in team problems experienced by more or less effective teams. Table 8.12 quantifies the problems associated with each effective multi-functional team and each multi-functional team given a mixed rating of effectiveness, drawing information from Tables 8.1, 8.2. and 8.3 and 8.9.

Table 8.12 Team Problems Of Effective Multi-Functional Teams And Multi-Functional Teams With Mixed Ratings

NB. Information given is the sum of problems associated with each multi-functional project team drawn from Tables 8.1, 8.2 and 8.3.

Company Teams	Multi-functional Teams With Mixed Effectiveness Ratings	Effective Multi-functional Teams
1	7	0
2	12	1
3	14	6
4	12	2
5	10	5
6	7	5
7	4	
Total Team Problems	66	19
Number of Teams	7	6

Using the Mann-Whitney test there were significant differences between effective multi-functional teams and multi-functional teams with mixed effectiveness ratings in terms of their experience of problems, at the .05 level of significance. This confirms that the multi-

functional teams rated as effective experienced fewer problems than multi-functional teams with mixed ratings of effectiveness:

$$W = 67.0$$

The test is significant at 0.0121 level, which is significant at the 0.05 level.

Table 8.13. presents the relationship between the effectiveness of different team types and their problems with team operations. Since sample size is different for each group, intra-group not inter-group comparisons can only be made, thus:

- Effective multi-functional, single-disciplinary and multi-disciplinary teams experienced the most problems with external relationship issues;
- Multi-functional teams with mixed ratings of effectiveness experienced the most problems with team interaction and task management;
- Single-disciplinary teams with mixed ratings of effectiveness experienced the most problems with task management;
- Multi-disciplinary teams with mixed ratings of effectiveness experienced the most problems with team interaction issues.

Table 8.13. Problems Associated With Effective Teams And Teams With Mixed Ratings

Abbreviations:  
MFT is a Multi-functional team;  
SDT is a Single-disciplinary team;  
MDT is a Multi-disciplinary team.

Team Operations	Effective MFT's	MFT's with mixed ratings	Effective SDT's	SDT's with mixed ratings	Effective MDT's	MDT's with mixed ratings	Total
Team Membership	6	11	4	1	7	3	31
Team Interaction	2	23	0	2	3	5	34
Task Management & Planning	4	23	4	3	5	2	40
External Relationships	7	9	6	2	11	2	35
<b>Total</b>	<b>19</b>	<b>66</b>	<b>14</b>	<b>8</b>	<b>26</b>	<b>12</b>	<b>145</b>
<b>N</b>	<b>6</b>	<b>7</b>	<b>3</b>	<b>1</b>	<b>6</b>	<b>1</b>	<b>24</b>



**8.5.4. Team Effectiveness And Positive Aspects Of Team Operations**

Table 8.14 quantifies the positive team operations associated with each effective team and each team with a mixed rating of effectiveness, drawing information from Tables 8.1, 8.2, 8.3 and 8.9. Effective teams include all effective multi-functional, multi-disciplinary and single-disciplinary teams. Teams given mixed ratings of effectiveness also include all appropriately rated multi-functional, multi-disciplinary and single-disciplinary teams.

Table 8.14 Positive Team Operations In Effective Teams Versus Teams With Mixed Ratings

NB. Information given is the sum of positive and learning aspects associated with each project team's operations drawn from Tables 8.1, 8.2 and 8.3.

Company Team	Effective Teams	Teams with mixed ratings of Effectiveness
1	6	1
2	12	3
3	4	6
4	4	5
5	0	11
6	0	6
7	7	0
8	2	3
9	2	7
10	3	
11	9	
12	9	
13	2	
14	3	
15	2	
Total Positive Team Operations	65	42
Number of Teams	15	9

The Mann-Whitney test showed that the differences between effective teams and teams with mixed ratings of effectiveness in terms of positive team operations were not significant at the .05 level of significance. So although effective teams appeared to have more positive team operations than teams with mixed ratings of effectiveness, these differences were not significant:

$W = 181.5$

The test is significant at 0.7413 (adjusted for ties) which is not significant at the 0.05 level.

**8.5.4.1. Positive Team Operations In Effective Multi-Functional Teams And Multi-Functional Teams With Mixed Ratings**

Were there differences between effective and less effective multi-functional teams, single-disciplinary teams, multi-disciplinary teams in terms of positive team operations?

It was possible to test the significance of the difference between the positive aspects of team problems in effective multi-functional teams versus multi-functional teams with mixed ratings of effectiveness. The sample was too small to compare within single-disciplinary and multi-disciplinary teams. Table 8.15 quantifies the positive aspects of team operations associated with both each effective team and each team given a mixed rating of effectiveness, drawing information from Tables 8.1, 8.2. and 8.3 and 8.9.

**Table 8.15 Positive Aspects of Team Operations In Effective Multi-Functional Teams And Multi-Functional Teams With Mixed Ratings**

NB. Information given is the sum of positive and learning aspects associated with each multi-functional project team's operations drawn from Tables 8.1, 8.2 and 8.3.

Company Teams	Effective Teams	Teams With Mixed Ratings of Effectiveness
1	6	1
2	12	3
3	4	6
4	4	5
5	0	11
6	0	6
7		0
<b>Total Positive Team Operations</b>	26	32
<b>Total Number of Teams</b>	6	7

Using the Mann-Whitney Test of Significant Differences in Positive Team Operations Between Effective Multi-functional Teams and Multi-functional Teams with Mixed Effectiveness Ratings:

$W = 40.0$

The test is significant at 0.8282 (adjusted for ties) which is not significant at the 0.05 level.

Comparative analysis of the positive aspects of team operations in effective and less effective teams shows that multi-functional teams with mixed ratings of effectiveness had a



*greater* number of positive team operations than effective multi-functional teams, although this difference was not significant at the .05 level of significance.

**8.5.5. Comparisons Of Team Effectiveness And Satisfaction**

By relating ratings of satisfaction and effectiveness in Tables 8.8. and 8.9. to the detailed information on team operations presented in Tables 8.1, 8.2. and 8.3, it can be seen that the experience of problems did not necessarily lead to ratings of low satisfaction or poor effectiveness, although greater numbers of team problems were significantly related to mixed ratings of team effectiveness. Furthermore, this information shows that there was not a direct relationship between the experience of satisfaction within a team and perceptions of team effectiveness.

Were ratings of team satisfaction significantly related to ratings of team effectiveness?

Table 8.16 draws information from Tables 8.8 and 8.9 for the purpose of conducting a *Chi-square* analysis to test for the significance of the relationship between perceptions of effectiveness and satisfaction.

Table 8.16 Relationship Between Team Ratings of Effectiveness And Satisfaction

Effectiveness		Satisfaction	
more effective teams	15	more satisfied teams	19
<i>expected</i>	<i>17</i>	<i>expected</i>	<i>17</i>
teams with mixed ratings of effectiveness	9	less satisfied teams	5
<i>expected</i>	<i>7</i>	<i>expected</i>	<i>7</i>

The results show:

*Chi* observed 1.613 was less than *Chi critical* of 3.84.

This was not significant at the .05 level.

This suggests that these ratings were not significantly related.

This result suggests that perceptions of team satisfaction should be distinguished from perceptions of team effectiveness. Furthermore, the measurement of satisfaction cannot substitute for the measurement of effectiveness. Some of the following examples may help to explain how project teams, on the one hand, may regard themselves as effective but not satisfied with the experience of the project team and project outcomes, or on the other, satisfied without being effective as a team.

Datalog and R&D Laboratories were perceived to have adopted a team approach which, whilst not satisfactory for all team members, was nonetheless effective.

### **Datalog**

The Development Manager and all the team members believed that the team was effective or very effective and largely attributed the project success to the team effort despite the many external problems which affected them. One team member explained the effectiveness of the team from a negative perspective. 'Had there not been the support which the team gives you, then it would have been even more difficult to turn up for work than it already was. I would say at times we derived some comfort from the team'. Another team member pointed out that the frustrations with the company were diffused by being part of a team. However, to describe the experience as satisfying would be going too far for some of the team members.

### **R&D Laboratories**

The team experience was good until the time staff were laid off. There were other negative aspects to the team which affected satisfaction. For instance, team members were contract workers whose contribution was project-limited since they were expected to move on when the projects ended. Furthermore, many were eventually 'let go' without pay when the company got into difficulties. No matter how many social outings they had, and irrespective of whether people were given flowers when they were ill and cakes to celebrate their birthdays, this situation clearly reduced satisfaction.

The team members from Water Services, Sensorval, Longman Engineering and Biogentech were not convinced of the effectiveness of their team approach to innovative project developments but had found the experience very satisfying and a major learning experience.

### **Sensorval**

The R&D Director admitted the overall effectiveness of the co-ordination of the three team was not great. However, she had learned a lot and would approach inter-company project management differently next time, particularly in terms of enforcing deadlines. 'With this product we were learning as we went. Next time we will do it better'. However, she did not think that they could have planned this project tightly because of the requisite inventive and experimental work for a major company innovation.



### **Longman Engineering**

Although the New Business Executive was personally satisfied with the projects, he had some 'sleepless nights' as a result of some technical and organisational problems. He felt that the team approach could have clearly been more effective, but pointed out that their experience with the first project was a good learning experience which enabled them to put in place sound project management principles which would help them to identify problems before they arose in subsequent projects.

### **Biogentech**

When questioned about how effectively the team had approached the project, the Managing Director replied 'some would say badly'. It was clear that his approach to the co-ordination of the five teams involved with the development of a pollution diagnostic product was a key determinant of effectiveness, particularly since communication was centralised in the co-ordination role. He pointed out that although he gets 'a buzz from the commercial side. The core of my soul lies in the technology'. In evaluating the effectiveness of their approach, he pointed out that 'Ultimately, you learn as you go along to find the best way'. He thought that he has been as effective as he could when considering the innovative nature of the project, the unpredictable nature of the technology and the constraints on available resources.

The cases above suggest that teams may be satisfactory without being rated as effective when the team is on a learning curve associated with the development of an innovative project. On the other hand, the explanation for teams rated as effective but unsatisfactory usually lay in the experience of interaction problems within the team or company.

## ***8.6. The Value Of Multi-Functional Team Approaches***

The literature review in Chapter 2 suggested that the multi-functional team may benefit the management of innovation by:

- breaking down inter-functional rivalries and improving multi-functional integration;
- assisting the cross-fertilisation of ideas;
- reducing costly product design amendments;
- producing a higher quality product;
- improving market targeting and time-to-market;
- improving plans for product families;

- achieving financial benefits, such as greater profitability, greater market share and reductions in development costs.

Do multi-functional teams deliver these benefits? The results show that the multi-functional team does not offer a panacea for the problems associated with the integration of staff from different functional backgrounds and the expected benefits were not automatically delivered.

Multi-functional teams did not experience significantly fewer problems than multi-disciplinary teams and single-disciplinary teams. In general, multi-functional team experienced the greatest number of problems with task management; multi-functional teams with mixed ratings of effectiveness also experienced many problems with the interaction of team members. The research also shows that multi-functional teams experienced problems in areas where benefits might be expected. An examination of 13 multi-functional teams shows that problems were experienced with:

- multi-functional integration in 6 companies (i.e. 46 % of multi-functional teams): Engineering Projects, EMS, Wasserpur, Analytik (1), Sensorval and Longman (project 2);
- costly product design amendments in 3 companies (i.e. 23 % of multi-functional teams): Engineering Projects, Sensorval and Greenwater;
- poor market targeting in 1 company (i.e. 8 % of multi-functional teams): Engineering Projects;
- poor market timing in 1 company (i.e. 8 % of multi-functional teams): Engineering Projects (although other companies were unhappy with the development-time the resultant time-to-market was good, including EMS, Wasserpur and Sensorval);
- poor product family planning in 1 company (i.e. 8 % of multi-functional teams): Cheminstrum;
- poor financial profitability in 3 companies (i.e. 23 % of multi-functional teams): Engineering Projects, Analytik (Project 2) and Greenwater.

However, some multi-functional teams clearly achieved some of the benefits associated with multi-functional teams. Benefits were clearly evident with:



- improving multi-functional integration in 7 companies (i.e. 54 % of multi-functional teams): Analytik (Project 2), Innovconsult, Cheminstrum, Greenwater and Filtratec (Projects 1 and 2);
- assisting the cross-fertilisation of ideas in at least 5 companies (i.e. 38 % of multi-functional teams): Biogentech, Sensorval, Innovconsult, Analytik (Project 2) and Wasserpur;
- reducing costly product design amendments in at least 1 company (i.e. 8 % of multi-functional teams): Wasserpur;
- producing a higher quality product in 12 companies (i.e. 92 % of multi-functional teams): Engineering Projects, EMS, Wasserpur, Analytik (Project 1), Innovconsult, Biogentech, Cheminstrum, Greenwater, Filtratec (Projects 1&2), Sensorval and Longman (Project 2);
- appropriate market targeting in at least 10 companies (i.e. 77 % of multi-functional teams): EMS, Wasserpur, Analytik (Project 1 & 2), Innovconsult, Sensorval, Biogentech, Cheminstrum and Filtratec (Project 1& 2);
- appropriate time-to-market in 7 companies (i.e. 54 % of multi-functional teams): EMS, Wasserpur, Analytik (Project 1), Sensorval, Biogentech, Cheminstrum and Filtratec (Project 1);
- improving plans for product families in 4 companies (i.e. 31 % of multi-functional teams): Analytik (Project 1), Sensorval, Biogentech and Longman (Project 2);
- achieving greater profitability in 6 companies (i.e. 46 % of multi-functional teams): EMS, Wasserpur, Analytik (Project 1), Innovconsult, Cheminstrum and Filtratec (Project 1).

Chapter 9 continues this analysis to consider the commercial and technical outcomes associated with the adoption of multi-functional team approaches. The present Chapter elucidates the nature of multi-functional team problems and the difficulties experienced by companies implementing these team approaches. The following case report on Datalog illustrates the doubts held by a company beginning to use multi-functional team approaches.

## Datalog

For new projects Datalog intended to adopt a more multi-functional approach involving software, technical and marketing people early on in an attempt to pin down a clear product specification. They were undergoing organisational change from the traditional linear approach, not altogether successfully. The Development Manager said that 'people that have been used to that approach will say, even though they are part of a multi-functional, concurrent engineering team, 'Oh it doesn't affect me yet', until suddenly sitting at a meeting they realise 'I'm supposed to have bought that bit 10 weeks ago. Then the team grinds to a halt'.

Other team members believed that multi-functional teams were 'probably a good idea in theory because it encourages everyone to agree the boundaries and the specification as early as possible and get opinions from all functional groups, but empowerment and delegation of authority is crucial for its effectiveness. If it is not facilitated from the very top level, it is doomed to failure'.

But another team member believed that there was a danger that 'you will end up with a bunch of individuals each with their own hidden agendas, trying to deflect as much of the pressure from themselves with some poor 'bugger' (*sic*) trying to drive the project and make a team out of it'. Furthermore, planning is wrecked 'if the team leader gives somebody a job to do next week and their boss gives them a job which lasts for 1½ weeks'. Working multi-functionally may also be difficult because of the different ways different functions have of working, for example some team members thought that production engineers were 'doers' rather than 'thinkers' which would make it difficult for them to think in advance. Furthermore, if the team members are located all around the company rather than in close proximity, then you may not get the same team spirit as you do with the single-disciplinary team approach.

The following case reports on Engineering Projects, EMS and Wasserpur illustrate team problems associated with poor compatibility between team members, coming from different functional backgrounds, which led to poor product development time. Furthermore, the cases of EMS and Engineering Projects raise issues about the appropriateness of the project leadership, where an uncomprehending marketing function could not manage the R&D experimentation stage nor understand the delays, which led to cross-functional blame and lack of shared overall responsibility for project outcomes. Furthermore, the case reports on Sensorval and Biogentech below show how problems with team interaction are influenced by the inter-company dimension to multi-functional team approaches.



### **R&D Blamed For Slow Development Time**

In Engineering Projects, the development work on the environmental safety monitoring project was led by the marketing function which directed the contributions from R&D and production. Relations between R&D and marketing were problematic and the Marketing Director blamed the R&D team for the slow development-time. Time lost at the R&D stage indicated that the problem was associated more with the uncertainty of inventive work and R&D operations than with the co-ordination of the team approach.

In frustration, the Marketing Director said that 'only 10% of all R&D is worth anything at the experimental stage. Sales-oriented staff get so frustrated with the boffins because first of all they go down tracks of experimentation and produce nothing then you get them down a track and it is looking good, you are all excited, you prepare a marketing plan and suddenly they find something which screws it all up'. R&D staff began with the attitude that they would crack the inventive work in six months but then deadlines drifted. However, he admitted that 'if it (the innovative idea) were simple someone would have thought of it a long time ago'. Such problems are unlikely to arise again because when they develop the Mark II and III of the product since R&D staff will not be involved.

### **Difficulties In Relations Between Marketing And R&D**

The environmental monitoring product under discussion at EMS was directed by the marketing function. Marketing tended to direct R&D which was located within a hierarchical marketing department. Although the Marketing Director mentioned that they experienced few problems, the team approach appeared to be the source of some of the problems experienced on this development project, such as slower than expected development time. Like the Engineering Projects, the EMS Marketing Director blamed this delay on the R&D staff who were 'not as commercially-minded as they should be'. Thus deadlines tended to be missed by R&D, probably as a result of both poor development estimations and R&D perfectionism. He thought that this might be a typical problem with R&D staff and said 'My experience with R&D is that it takes twice as long and costs twice as much as everyone thought at the outset'. However, he admitted that realistic estimations of time for project development and market launch may also be hampered by the pressure R&D were put under by marketing staff 'who want the product tomorrow or rather yesterday once they have identified a requirement'. Furthermore, they have tended to use previous estimations and plans to make new project plans rather than reviewing the results and actual time taken on previous project developments.

According to the Marketing Director, the team approach could have been more effective. There were clearly problems with planning and timing, poor project management procedures and poor relations between the R&D and marketing teams. Due to the costs of slow development time, the Marketing Director had recently decided to involve R&D with more project management controls and management techniques, such as time-sheets and 'gant' charts.



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As with Engineering Projects, this case raised the question of the appropriateness of the marketing function leading the R&D effort, if R&D are blamed for delays when they have been pressurised by Marketing to give unrealistic estimations of project development-time. On the other hand it may have been the case that R&D were incapable of giving realistic estimations as a result of the uncertainty of their work or their perfectionist approach and would benefit from the more commercial leadership of marketing and the new emphasis on project planning techniques.

### **Clash Between R&D Capabilities And Marketing Requirements**

In the course of the water purification product development at Wasserpur, the design specification changed a few times as marketing requested a low cost and high quality product which R&D regarded as 'impossible' and 'stupid'. So on a number of occasions during the project they had meetings at which they discussed cost versus product quality issues. 'You get a wish-list from marketing and they want the earth. We sit down and see what is possible, what is feasible, what things will cost and we get our ideas together and then discuss it, agree what is reasonable and identify what they really want and where they want to stop spending money'.

Like Engineering Projects and EMS, R&D were pressed by marketing to make better product timing than they managed. However, delays followed the decision to subcontract the product design work to an external design consultancy, which took more time than expected. The Project Manager said that he did not see how this slow business could be improved because 'unless you're extremely lucky and it all drops into place first time, it is likely to be a bit iterative and this certainly was'. Although he had advised marketing that the time-scales were unrealistic, he was told to get on with it anyway and so it was not unexpected when the work took an extra six months to complete. The Product Manager said 'I didn't think we could actually meet the deadlines that were set. Nobody wanted to listen at the time but they will in future'.

### **Difficulties In Managing The Involvement Of Several Companies**

In Sensorval, the R&D Director contrasted the experience of managing in-house minor innovation development projects with a more innovative collaborative project, involving two other companies with the development of a pollutant-detection product. The less innovative project is typically more predictable, controllable and desirable. On the basis of this experience, she said 'I didn't expect to have any hands-on time with this and I did not expect any of my staff to do so. I thought that all the work would happen with the other companies and I could swan along and take the credit. ...I thought I would handle it by hands-off management and having meetings with everyone involved every couple of weeks, keeping regular contact and daily telephone contacts'. But they did not make much progress this way after one of the collaborating companies failed to meet deadlines.



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Although there had been many problems, the biggest were associated with the failure of one partner team (a new partner, since the other two partners had worked together before) to perform to specification and on time. This had led to postponing the launch date.

In the early stages, the new partner had probably underestimated the work required because the staff were keen to win the contract and knew that Sensorval were talking to other companies. However, it is possible that the staff from the partner company believed they could complete it as easily and quickly as they led Sensorval to believe. The new partner gave deadlines little thought, perceiving the real achievement to be the winning of the partnership contract. 'The problem is that they were a research-oriented group and they did not have a clue about time-management. They did not know that when they signed an agreement that said here is the date we are going to launch, that we intended to launch on that date. They thought here is an agreement which says we are going to do some work.' The R&D Director found after returning from a trip that no one had done any work in her absence and instead the teams awaited her return. She found this unbelievable because she had been in contact on a daily basis and had delegated authority to one team member.

Some of the problems with the lagging staff from the partner company were attributed to their academic orientation. The R&D Director found that they were more interested in trying out new ideas. She said 'Before you start any project you have to know that you are going to sell enough of it to cover your research costs and generate a good profit for the company and you have got to know that you have a 95% chance of bringing the product to market....They are happy when they have 90% of the job done to turn their attention to something else and that last 10% is what makes something that sells'.

Other problems were associated with the new partner's lower commercial and quality standards. The R&D Director discovered that she needed to check the quality of all their work. They tended to stray from the commercial remit and always urged Sensorval to pursue new ideas which would have involved additional work for the third partner when brief feasibility studies proved the ideas to be invalid and a waste of time from a commercial perspective. The R&D Manager pointed out 'I have had to say no, an awful lot of the time and appear really awkward'.

These issues would not have become so problematical for project development if the new partner had been honest about how far they had gone with their development work but instead she eventually found that they had been fudging about their progress. The R&D Director said 'It was a long time before they trusted us enough to give us the information'. So Sensorval's initial *laissez-faire* approach to external project management had to become heavier and more carefully planned to ensure that the project development met its original targets.



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Inter-company project management was difficult. The R&D Director pointed out 'the problem with external product management is that everyone has their own agenda and the impact of this depends on where they see my project amongst their list of priorities'. However, she added 'with flattery, cajoling and persuading I can have them working early and late and weekends getting the job done. By judicious communication you have to get your project promoted up their priorities somehow'.

Commenting on the differences between internal and external project management, she also pointed out that 'external product management is much more difficult as far as communications are concerned, because I cannot just walk in and see what people are up to. With internal product management, I am in charge of people and can tell them what to do. With external management you have to be more tactful'. She expected that the satisfaction of the team members associated with the new partner team was dented by her heavy handed project management approach, her reluctance to divert from the commercial objective for the product and her unwillingness to throw money at the project, but the anticipated profits might make up for it. She said 'without our management they wouldn't have a product and certainly not a saleable product'. This approach helped them to meet product launch targets and capitalise on being first to market with a major innovation. Furthermore, all three company teams intended to work together on future projects.

#### **Difficulties Within A Joint-Venture In Managing Several Teams In Different UK Locations**

**Biogentech** was set up as a joint venture to commercialise rapid diagnostic technology. The Managing Director described problems with the joint-venture partnership as a softer problem to the more challenging technical problems faced on this major company innovation project. The partnership problem was associated with the different organisational cultures and different perspectives of the partners. The major share-holding partner was a large water utility which was less commercial, although concerned that their money was managed well and were more willing to wait for results than the other partner, a technology consultancy which was more cash conscious and more interested in short-term results. The issue was further complicated by the dual role of the minority shareholder, both as contractor and share-holder and their over-willingness to spend the other shareholder's money with over-priced services.

When asked how he was coping with these problems the Managing Director replied 'some would say badly, I am fed up trying to take hassle from both sides'. He mentioned that 70% of all joint-ventures fail which is a 'grim statistic'. This usually occurs because one partner becomes so dominant that the other is bought out or the business fails because of poor relations.



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There were also minor problems associated with working with different functional groups, particularly academics who were often commercially naive. The Managing Director said 'In general most academics get more turned on by the technology and less by the commercial side'. This created planning problems with academics who needed to be reigned back to the project and encouraged to focus on agreed objectives.

There were further problems associated with the lack of geographical proximity between the five teams involved with the project team approach. The Managing Director pointed out that 'The problem is not just the time you lose, but the problem associated with not being there all the time, so you find out about problems retrospectively rather than at the time they are happening. There is an element of frustration in the knowledge that the problem could have been averted and you have lost another couple of days. There is only so much that you can do on the phone'.

However, many benefits associated with multi-functional teams were present and Section 8.6 showed that they experienced more positive team operations, particularly in the area of task management. Furthermore, multi-functional teams with mixed ratings of effectiveness reported more positive aspects of their team operations than effective multi-functional teams, due to the requirements for learning following organisational changes and the challenge of inter-company liaisons. Multi-functional teams may be beneficial when carefully implemented, as the following cases show.

#### **Staff Tenure and Small Team Size Can Alleviate Communication Difficulties In Multi-Functional Teams**

In Wasserpur, the Project Manager thought that the multi-functional team approach was valuable for project success. It helped particularly at the ideas stage 'Personally I'd prefer to involve as many people as possible in throwing in their ideas and pick the best out of the bunch'.

He thought that communication problems would always be associated with multi-functional team approaches. He said this 'because you're going to have difficulty specifying to one discipline what you want from them and therefore getting the best performance from them'. However, when team members had a long tenure within the company and the teams were kept small, these problems could be minimised since multi-functional awareness would probably rub off on team members in these circumstances. He said 'the smaller the team the better, the more one discipline understands about the other discipline the better, but that takes time. We've got an electronics engineer who does understand our processes reasonably well because he has been here umpteen years. We've got mechanical engineers who understand the



*Continued.*

process pretty well for the same reasons, so it means that you don't have to go back to specifications' with one discipline saying 'oh you didn't tell me that' and instead they might ask early on 'well are you sure you really want to do that?' He did not find it easy to manage people with a different disciplinary expertise to his own, but he thought that 'the overlap is made more effective when the people themselves think across the boundaries and put themselves in the other guy's position'.

He thought that 'if we had put more effort into documentation as we progressed, we would have had a few less misunderstandings or at least we could have had better records of exactly what we've done. That would have eliminated any communications problems and misunderstandings. We probably could have progressed the whole thing more rigorously, but then it's nice to have a reasonably relaxed atmosphere at work.

### **Value of Informal Communication and Tightly Co-ordinated Teams**

In the small company **Filtratec**, the Technical Director pointed out 'We naturally adopt a multi-functional team approach...communication is easy, we can shout across at each other when we need to'. He thought that multi-functional team approaches were useful but could become a problem when the team became too big or when authority was dispersed.

### **Importance Of Staff Awareness Of Whole Innovation Process And Early Agreement Of Specification**

In **Analytik**, the Design and Development Manager thought that in order to manage projects concurrently it was important to ensure 'the visibility of the workload' by which he meant that if people can see the workload ahead and are aware of the consequences of delays for staff further down the line, they can see where they fit into the overall operation and so can work much better. The 'visibility of the workload' is achieved by making project plans openly available on computer technology.

Furthermore, irrespective of whether projects are more or less innovative they now insist on a fully working design before production. 'Up until now there has been the idea that the more innovative the project is, the more woolly the engineering design is, when it leaves the engineering department to be handed over to the production department. This leaves significant loose-ends to be tied up by production. It is the over-the-wall, the baton-passing type of approach which tends not to work'. To avoid this, they now insist, that the final design is 'frozen' (with respect to the product manufacturing process) at the pre-production phase, although it does not always work because of restrictions on the departments' resources.

#### **8.6.1. Better Team Practices**

Observations of team operations showed that all teams, multi-functional, single-disciplinary and multi-disciplinary, both effective and ineffective, experienced problems.



The evaluation of team operations offered ideas on better practice in team operations and provide insights for team building. These ideas are grouped below under the headings of team membership, team interaction, task management and planning issues and external relationship management.

### Team Membership

1. Ideally, team size should not be so small that expertise is limited and inadequate to meet the workload.
2. Little management is needed with small teams if members have expertise and are goal-oriented.
3. Team member characteristics are important, such as a work ethic, the compatibility of members expertise, knowledge of project goals and methods, energy, communication skills, happiness with the project work and a commitment to project and team.
4. Team motivation may be heightened in small companies which offer the excitement of informal interactions and involvement with projects from beginning to end.
5. Team motivation may grow when there is peer pressure and when members identify with the team and invest their ego in the project.
6. Uncertainty about post-project prospects undermines staff motivation and creates recruitment difficulties for later projects if staff move on.
7. Multi-tasking outside areas of personal expertise can lead to time wastage.
8. It is important to realise that team members may have conflicting work or personal agendas; e.g. academics may have research agendas which conflicts with the commercial agenda of companies.
9. Failure to consult and trust in production experts and other project associates early on can slow down product development.
10. Since project management can be very people-orientated, success outcomes may depend on the ability of the project manager to assess people and companies in terms of their capability and reliability.

### Team Interaction

1. Team communications can promote idea-generation and facilitate the best choice of innovative idea.
2. Keeping teams small and promoting long-term staff tenure as well as encouraging staff to think beyond boundaries can alleviate the communication problems which typically arise in multi-functional project teams.
3. Informal communication can facilitate inter-functional integration. It may be supported by both close proximity of staff and a frequent in-house staff presence.
4. The bigger the project (involving several teams and companies) the more likely there are to be co-ordination problems and excessive project bureaucracy. Therefore it is important to have well-defined channels of communication through the project managers, since too much cross communication is difficult to manage.
5. Decision-making is slowed and co-ordination problems are exacerbated if the teams are not located in close geographical proximity.
6. Teams which have become over-cohesive may find the transition to new projects and teams difficult and therefore the transition to new project teams needs to be sensitively managed.
7. In large teams, authority can be dispersed which can make the leadership function difficult to maintain.
8. There may be project planning difficulties if the R&D function is not understood sufficiently well on marketing-led projects for the following reasons: invention may not be easily managed and timed; R&D may be pressurised to give unrealistic estimations by enthusiastic marketers; R&D may be more concerned with perfection than deadlines.
9. Leadership should be strong, but an overly egalitarian approach may lead to time wastage and the failure of leadership to take ultimate responsibility for the project.
10. Inter-functional integration could be helped by addressing R&D's perception of marketing as over-demanding and marketing's perception of R&D as perfectionist and slow.



11. Project management may be enhanced if project leaders are goal-oriented, move fast and are able to see the wider potential of the innovative concept.
12. Team building may be promoted if team members are given ownership, responsibilities and reasonable challenges within the project and if organisational support for the project is built up through good communications with the rest of the organisation.

### Task Management And Planning

1. With competitive pressures it may be important that project goals extend to future business beyond the present project.
2. It is important to plan projects using evaluations of previous project outcomes rather than depending entirely on previous project plans or wish-lists.
3. Rigorous early project planning and the early involvement, agreement and concurrent working of all project associates may be important for rapid project development.
4. Multiple and conflicting work demands can be very stressful for staff and counter-productive for the organisation when they involve either the requirement to work on several projects simultaneously or to perform functions which potentially clash, such as project development work and technical service provision. A service role may not be compatible with a development role. However, performing both roles may be a broadening experience, although it may be difficult to work in both a service and development role on a day-to-day basis.
5. Pressurised company environments focused on getting more productivity from fewer workers may create problems for resourcing projects.
6. Inexperience in new areas of innovation project developments or commercial activity tends to lead to underestimations of project resourcing requirements, including time, staff and finance. Inexperience may also lead to false assumptions about how staff, teams and companies will work together.
7. Organisational changeover to new innovation management approaches that involve a different use of staff resources may pressurise those resources when requirements for old and new projects peak at the same time.

8. It is important to distinguish between the inventive phase of technology development in the innovation process and the later phase of developments applications since the former is more uncertain and difficult to manage than the latter which is usually more straightforward.
9. It may be important that there is openness on project plans with staff involved so that the staff involved at early phases of the project are aware of their responsibilities towards staff involved at the later stages.
10. An emphasis on the documentation of plans, procedures and progress can help to clarify communications in project development.
11. Flexibility with plans and staff resources may be necessary to achieve goals; the important thing to focus on is the final goal.
12. Post-project evaluation can be useful for considering the effectiveness of the project management approach and whether the project could have been carried out more cheaply, or more in line with product manufacturing and maintainability issues.
13. Time-sheets and intra-company comparisons of different project success outcomes may assist post-project evaluation.

#### External In-house and Inter-Team Relationships

1. Project development teams need the authority or support of senior management to ensure that project associates co-operate with project development requirements.
2. The management of the team's transition to new projects or teams needs to be managed in a non-destructive way which is sensitive to team member bonding and team members' value of their team and which recognises the potential of team members to form again in teams for future projects.
3. Inter-company teams can embarrass team members if there is a differential in the project related powers, particularly the financial power of peers from different companies. Inter-company teams provide opportunities for comparisons of company approaches to organisation and management and unfavourable comparisons can reflect badly on a company unless used as an opportunity for organisational learning.



4. Outsourcing and inter-company project management can create difficulties because of lowered power to command and a reduced awareness of what is going on in other companies. This is of particular concern if companies involved feel obliged to 'fudge' about their capabilities and progress in order to win and retain the business association. With no right to command staff in partner companies, this may emphasise project management skills of cajoling and persuasion.
5. Different agendas may characterise the companies involved with inter-company projects which may require clarification. Project managers may need to guess how much heavy management is required or expected by the other companies involved.
6. Co-operation in inter-company relations rather than the exploitation of partners for short-term gains may be important for promoting long-term associations.
7. Dependencies on partners to perform essential business survival activities may be disastrous particularly for small companies if the partnership sours.
8. Inter-company teams may be promoted through loyalty to contractors.
9. Inter-company relations may be enhanced by considering differences in culture, values, priorities, attitudes and operations of partners early on and this information may come from discussions, company information and organisational charts.

### **8.7. Summary**

Chapter 8 has explored team ratings of team effectiveness and satisfaction and compared these ratings to the positive and problematical aspects of team operations. Team processes have been elucidated by both qualitative and quantitative analysis, although the quantitative findings were only indicative of trends which should be followed up with further research. Unlike multi-functional teams, members associated with single- and multi-disciplinary teams tended to rate teams as more effective and satisfactory than not. Multi-functional teams were given more mixed ratings of effectiveness. However, teams rated as effective were not always rated as satisfactory and *vice versa* and there was no statistically significant relationship between ratings of effectiveness and satisfaction. There were suggestions in the case reports that ratings of satisfaction not accompanied by team effectiveness may be explained by the satisfying learning experience afforded by the opportunity to work on a new type of project, whereas ratings of effectiveness not accompanied by satisfaction may be explained by 'team interaction' problems.



Differences in the team problems experienced between multi-functional teams, multi-disciplinary teams and single-disciplinary teams were not statistically significant. In general, the five most common specific team problems were with organisational resourcing and support; inter-company team relationships; the division of labour and responsibility; meeting set objectives; and team size which was usually too small in terms of available expertise. The biggest problem area in multi-functional team operations was task management. Multi-functional teams with mixed ratings of effectiveness experienced the greatest number of problems with team interaction and task management. The least number of problems experienced by multi-functional teams were with the management of external relationships, both in-house or inter-company. By contrast, this was the biggest problem area for single-disciplinary and multi-disciplinary team operations in general.

Differences in team problems experienced between satisfactory teams and less satisfactory teams were not statistically significant. However, effective teams experienced significantly fewer team problems than teams with mixed ratings of effectiveness. Furthermore, effective multi-functional teams experienced fewer team problems than multi-functional teams with mixed effectiveness ratings. Generally, the results suggested that less effective teams experienced the greatest number of problems in the areas of team interaction and task management, whereas effective teams experienced the greatest number of problems in the area of external relationships. This suggested that perceptions of team effectiveness were determined by the quality of team interaction and the effectiveness of task management. Team problems with the management of external relations may be equally important for project success outcomes but have less impact on team member ratings of effectiveness.

Differences in the positive and learning aspects of team operations in multi-functional, multi-disciplinary and single-disciplinary teams were not statistically significant. An interesting finding was that multi-functional teams reported more positive or learning aspects of their team operations than single-disciplinary and multi-disciplinary teams, particularly in task management and planning. Furthermore, multi-functional teams with mixed ratings of effectiveness reported more positive aspects of their team operations than effective multi-functional teams. The greater number of positive team operations of less effective multi-functional teams were attributable to reasons, such as organisational change-over to the adoption of team approaches and the challenges to learn when developing major innovations which incurred inter-company dependencies.



However, although multi-functional teams appeared to have more positive aspects of their team operations, it was clear that a multi-functional team approach was not a panacea for the problems associated with the development of innovative products and processes and did not automatically deliver the alleged associated benefits of multi-functional team approaches. Multi-functional teams experienced problems frequently in team interactions and task management. Indeed several multi-functional teams mentioned particular problems with the relationships between different functional groups. On the other hand, at least 50% of multi-functional teams reported benefits in the following areas: improving multi-functional integration, producing a higher quality product, targeting the market appropriately and making good time-to-market.

The problems experienced by effective single and multi-disciplinary teams with the management of external relationships, either in-house or inter-team, suggested problems with the integration of different functional groups and project associates. Furthermore, this is supported by the difficulties experienced in the areas of task management and team interaction respectively by single and multi-disciplinary teams with mixed effectiveness ratings. The insights on how to manage teams better were drawn together in Section 8.5. which outlined ideas on how multi-functional teams and teams in general may be managed for greater effectiveness.

Since multi-functional teams had more mixed ratings of effectiveness than other types of team approaches but experienced the fewest problems with managing external relations which was the biggest problem area for effective teams, this might suggest that a team is more likely to be rated as effective if most team problems are experienced with external groups rather than within the team. This may be the case because external relationships may be regarded as separate from team operations and possibly beyond the team's control. So there were suggestions that the effort to bring on board greater inter-functional integration created more problems for internal team operations and may lead to perceptions of lowered team effectiveness. On the positive side, the multi-functional team brought more project expertise within the team boundary and under its control. The value of different team approaches may depend on the relative importance of perceived team effectiveness or greater team control of project expertise for ultimate project success outcomes. Chapter 9 conducts further analysis of the impact of different team types with varying effectiveness on project success outcomes which contributes to an understanding

of the value of different team approaches for team effectiveness and other project success outcomes.



# **Chapter 9 The Importance Of Team Approaches . For Success**

## ***9.1. Introduction***

Chapter 2 suggested that team approaches to innovation management are one of many factors which influence the commercial success of innovations. The literature on the commercial success of innovation suggests that important factors influence success including market, organisational, technological, project-related and human resource conditions (See Section 2.6). However, the literature also suggests that multi-functional team approaches and team effectiveness may be part of the profile of successful innovative project developments.

The question of the importance of team approaches and team effectiveness for the technical and commercial success of innovation is considered in this chapter. Section 9.2. classifies innovative projects in terms of the following outcomes, team effectiveness, technical success and commercial success. This classification allows for an analysis of the importance of team approach and team effectiveness for project success outcomes in Sections 9.3-9.5. Section 9.6 takes this analysis forward to consider the role of the team in influencing the commercial success of innovative projects using detailed case reports on projects with differential success outcomes.

## ***9.2. Classification Of Project Success Outcomes***

A wide range of criteria were used by the participating companies to measure technical and commercial outcomes as Box 1 and Table 9.1 reveal below. In this Section, these criteria are discussed in the context of decisions taken by the researcher on which project success outcomes to assess.

**Box 1**

Technical success may be measured by:

1. meeting the technical specification for product/process quality and performance.
2. the satisfaction of customer requirements, which could include cost reduction or profit generation.
3. compliance with government and EU regulations.
4. few or minor technical problems and few delays in the development programme and launch/delivery.
5. level of innovation as indicated by patents or scientific papers.
6. the product/process design quality in terms of manufacturability, maintainability and affordability.

Technical success indicators such as the level of innovation, manufacturability, maintainability and affordability of the innovative product and process could not be used to assess the technical success of all projects, because they did not generally reflect the goals of all teams. Furthermore, since most innovative work is associated with some technical problems, it was accepted that a project could be technically successful even if there had been technical problems and some set-backs in the development programme. Furthermore, products could be technically successful even when further developments could benefit the project, since this could reflect either technical perfectionism and pride or the potential for generating future product enhancements or families. For this research, technical success was indicated principally by indicators 1-3 above and by team satisfaction with the performance and quality of the project.

**Technical performance** is indicated by meeting the technical specification for product/ process quality and performance, the satisfaction of customer requirements, compliance with government and EU regulations and team satisfaction with the performance and quality of the project.

Commercial success outcomes valued by this sample of company projects varied as a function of the type of market and associated risk. Projects were grouped according to whether they were:

- entirely funded under contract by a client. This represented a low risk for four companies: Systems Engineering, Filtratec (project 1), Powerengineering, and Innovconsult;
- partially or completely funded either by a client or internally but also aimed at other markets. This represented a medium risk for eight companies: Datalog, Robinson Engineering, CWT Engineering, Biogentech, Longman Engineering (project 1) Water Services, Water Quality Utilities and Pollution Control Engineering;



- dependant on open markets for sales or contracts. This represented a high risk for sixteen company projects: R&D Laboratories, Engineering Projects, Wasserpur, Gulls Exports, Filtratec (project 2), New Carbon Ventures, Effluent Treatment Systems, Sludge Treatment Systems, Wind Power Projects, Greenwater, Cheminstrum, Analytik (projects 1 & 2), Sensorval, EMS and Longman Engineering (project 2).

Table 9.1 indicates the commercial success criteria which teams valued for projects directed at each type of market.

Table 9.1 Appropriate Commercial Success Criteria For Different Markets

Commercial Success Criteria	Client-funded projects	Partially or completely funded projects also for open markets	Projects aimed at open markets
Meeting budget and resource allowances	X	X	X
Breaking even/return on investment		X	X
Delivering profits & meeting sales projections		X	X
Making good time-to-market or delivery time to client	X	X	X
Appropriate market timing		X	X
Winning contracts	X	X	X
Satisfying contractors	X		
Satisfying customers	X	X	X
Securing repeat business	X	X	X
Company survival when it depends on project success		X	X

For client-funded projects, companies like Pollution Control Engineering pointed out that it is important that the resource allowances for the project of time, staff and money are not over-stretched. In the contracting business, slow delivery may be associated with penalty costs. Projects which exceed budgetary allowances make no profits and projects which overshoot on internal staff resources can create problems for other projects, even though this may not show up in financial terms.

For the projects aimed at winning contracts or sales on open markets, some of these commercial success indications varied in importance for companies, especially the time-to-market and the appropriateness of market timing. The appropriateness of market timing was particularly important for smaller companies, such as R&D Laboratories, whose survival depended on the success of their products in uncertain volatile markets. Larger companies, such as New Carbon Ventures, Robinson Engineering and Engineering Projects, were capable of waiting for the right time for entry in markets driven by

legislation enforcement. Furthermore, although fast time-to-market was generally a management concern in companies, project management was not always organised to optimise for this goal. In companies which did not adopt team approaches, such as Wind Power Projects, New Carbon Ventures, Gulls Exports and Effluent Treatment Systems, the project was a low and under-resourced priority, by comparison with the main business of the company where resources were typically over-stretched.

Another issue of relevance to the evaluation of commercial success was that several companies were working towards a longer term pay-off for their innovation financial risk-taking. For example, Longman Engineering, CWT Engineering, Sensorval and Biogentech all hoped to capitalise on the technology for further projects. Most evaluations of commercial success do not acknowledge the future potential of the project technology. However, while acknowledging the limitations of using commercial success indicators such as perceptions of profits and sales, it was deemed necessary within the confines of the present research time scales.

<b>Commercial performance</b> outcomes were evaluated in terms of whether they fulfilled team member expectations for sales or profits.
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Drawing on Table 8.9, Tables 9.2.-4 outline the team effectiveness and success outcomes of different team approaches. Company projects were classified according to the evaluation of team members as displaying:

- ‘satisfactory’ or ‘unsatisfactory’ technical outcomes;
- ‘poor’ commercial outcomes when there were no commercial returns;
- ‘moderate’ commercial outcomes when there were commercial returns but so far no return on investment expenditures;
- ‘good’ commercial outcomes when commercial outcomes met expectations and returned investment.



Table 9.2. Commercial And Technical Success In Single-Disciplinary Teams

Abbreviations:

*V indicates varied opinions*

*ROI = Return on Investment expenditure*

Companies	Team effectiveness	Technical success	Commercial success
Datalog	Effective	V- Satisfactory	Moderate- but budget overspent
R&D Laboratories	Effective	Satisfactory	Poor -impending liquidation
Longman Engineering (1)	Mixed Views on effectiveness	Satisfactory	Moderate- but no ROI as yet
Systems Engineering	Effective	Satisfactory	Good
Total = 4 company projects	Effective= 3 (75%) Mixed Views=1(25%)	Satisfactory =4 (100%)	Good = 1 (25%) Moderate =2 (50%) Poor= 1 (25%)

Table 9.3. Commercial And Technical Success Of Multi-Functional Teams

Abbreviations:

*C indicates continued development*

*U indicates that a project was not commercially launched*

*ROI = Return on Investment expenditure*

Companies	Team Effectiveness	Technical Success	Commercial Success
Longman Engineering (2)	Mixed Views on effectiveness	C- Satisfactory	Moderate- high expectations for future
Sensorval	Mixed Views on effectiveness	Satisfactory	Moderate-
Greenwater	Effective	C-Satisfactory	Poor- no sales but hope remains
Innovconsult	Effective	Satisfactory	Good
Biogentech	Mixed Views on effectiveness	C-Satisfactory	Moderate- high expectations for future
Cheminstrum	Effective	Satisfactory	Moderate -no ROI as yet
Filtratec (1)	Effective	Satisfactory	Good
Filtratec (2)	Effective	C- Satisfactory	U-high expectation for future
Engineering Projects	Mixed Views on effectiveness	C- Satisfactory	Poor- but still hope
EMS	Mixed Views on effectiveness	Satisfactory	Good
Wasserpur	Mixed Views on effectiveness	Satisfactory	Good
Analytik (1)	Mixed Views on effectiveness	Satisfactory	Good
Analytik (2)	Effective	C- Unsatisfactory & sidelined	U- never launched
Total = 13 company projects	Effective = 6 (46%) Mixed Views = 7 (54%)	Satisfactory = 12 (92%) Unsatisfactory =1 (8%)	Good = 5 (38%) Moderate =4 (31%) Poor = 2 (15%) Unfinished=2 (15%)

Table 9.4. Commercial And Technical Success Of Multi-Disciplinary Teams

Abbreviations:

*C indicates continued development*

*ROI = Return on Investment expenditure*

Companies	Team Effectiveness	Technical Success	Commercial Success
Robinson Engineering	Effective	Satisfactory-	Poor
Power-engineering	Effective	C- Satisfactory	Moderate- intended to further develop technology within client-funded projects
Water Quality Utilities	Effective	Satisfactory	Moderate- commercial objectives were not the project objective*
Sludge Treatment Systems	Effective	Satisfactory	Good- but markets dried up post project following acquisition
Pollution Control Engineering	Effective	Satisfactory	Good
CWT Engineering	Effective	Satisfactory	Moderate but no ROI as yet
Water Services	Mixed Views on effectiveness	C-Satisfactory	Moderate- commercial objectives were not the main project objective*
Total = 7 company project teams	Effective = 6 (84%) Mixed Views = 1 (14%)	Satisfactory =7 (100%)	Good = 2 (29%) Moderate =4 (57%) Poor = 1 (14%)

\* this was an internal development project for which there was a commercial spin-off for another company

In the majority of cases, team members agreed on project outcomes. The exception was Datalog where there were varied opinions on the success of the project.

**Datalog**

The water quality product developed in collaboration with Chemqual was rated as a success on several criteria associated with technical and commercial success. According to the Development Manager, despite a few minor technical problems, the product met the technical specification, performed well and satisfied customer requirements. The other three members of the technical team pointed out that further developments could improve the product, although basically it satisfied the customer requirements. However, there were several technical problems, particularly with the manual, which some customers felt compelled to re-write.

In terms of commercial success, the Development Manager said that it won a major UK contract and far exceeded the sales projections. However, the project costs exceeded the budget by 500%. Other team members said that they had no feedback on sales but they believed that the sales were not as good as they should have been. On the basis of this information it appeared that technical outcomes were satisfactory and the commercial outcomes moderate, although not ideal.

Four companies did not adopt team approaches and therefore have been dropped from the ensuing analysis because they constitute too small a sample for an exploration of differences in the success outcomes of team and non-team approaches. A larger sample



would allow for a more insightful statistical analysis. Chapter 6 has shown that the concept of ‘team approach’ is not a unitary concept but includes a diversity of team approaches. Furthermore, there is a diversity of non-team approaches and the innovation process may be co-ordinated by a variety of mechanisms (See Sect.2.2.5). This would suggest that any comparison of team and non-team approaches to innovation would need to take account and represent the diversity in each category.

However, it is clear from the case studies of non-team approaches that these approaches can be commercially and technically successful as the case of New Carbon Ventures discussed in Sect.5.6 demonstrated. The example of New Carbon Ventures shows that companies can be successful, irrespective of whether team approaches are used. In this case, it could be argued that a team approach might have led to greater ‘value engineering’, a cheaper product and ensured that the success of the project did not depend on chance recognition by senior management. On the other hand, the company typically adopted team approaches to commercial projects and perhaps would have needed to be extremely farsighted to commit team resources to a project which was essentially a diversification for the company.

### ***9.3. Were There Direct Relationships Between Team Approaches And Success Outcomes?***

Table 9.5. shows that 23 of 24 (96%) team projects attained satisfactory technical outcomes. With the exception of Analytik’s (project 2), the technical performance of all innovative project developments was satisfactory, although several companies continued to work on technical developments at the time of the interviews, including Datalog, Filtratec (project 2), Longman Engineering (project 2), Greenwater, Water Services, Engineering Projects, Biogentech, CWT Engineering and Powerengineering. Analytik’s (project 2) was abandoned as a result of pressure on staff resources in addition to concerns with working with unproven uncertain technology. Multi-disciplinary, single-disciplinary and multi-functional team approaches were all associated with satisfactory technical outcomes and this was not a source of variation between project teams.

Table 9.5. Team Approach And Technical Outcomes

Team Approach	Satisfactory Technical Outcomes	Unsatisfactory Technical Outcomes
Multi-functional	12 (92%)	1 (8%)
Single-disciplinary	4 (100%)	0 (0%)
Multi-disciplinary	7 (100%)	0 (0%)
Total	23 (96%)	1 (4%)

Table 9.6. shows that only 33% of the team projects attained good commercial outcomes, 42% attained moderate commercial success and 17% were commercially unsuccessful. Multi-disciplinary, single-disciplinary and multi-functional team approaches were all associated with good commercial outcomes. Although multi-functional team approaches were most frequently associated with good commercial outcomes, they also represented the most frequently adopted approach to projects with poor, moderate and good commercial outcomes and therefore produced the most diverse outcomes.

Table 9.6. Team Approach And Commercial Outcomes

Team Approach	Good Commercial Outcomes	Moderate Commercial Success	Poor Commercial Outcomes	Not commercially launched
Multi-functional	5 (38%)	4 (31%)	2 (15%)	2 (15%)
Single-disciplinary	1 (25%)	2 (50%)	1 (25%)	0 (0%)
Multi-disciplinary	2 (29%)	4 (57%)	1 (14%)	0 (0%)
Total teams	8 (33%)	10(42%)	4 (17%)	2 (8%)

Tables 9.5-6 suggested that multi-functional teams were not more typically associated with good technical or commercial outcomes than other types of teams. However, further analysis in Table 9.7, which classifies projects according to different types of markets, reveals that multi-functional teams were typically adopted to projects directed at open markets. Furthermore, all commercially successful innovative projects directed at open markets were developed by multi-functional teams.



Table 9.7. Team Approach And Commercial Outcomes In Different Markets

Abbreviations:  
MFT is a Multi-functional team; SDT is Single-disciplinary team; MDT is Multi-disciplinary team

NB 1: Two companies are excluded from this Table, Analytik's (project 2) which was abandoned pre-commercialisation and Filtratec's (project 2) which had not been fully commercially developed at the time of interview.

NB 2: Percentages are given for different markets

Commercial Outcomes	Fully client-funded projects	Partially or fully funded project also aimed at open markets	Dependant on open markets
Good Outcomes	1 SDT (20%) 2MDT (40%) 2MFT (40%)  Total 5 (100%)		3MFT (33.3%)  Total 3 (33.3%)
Moderate Outcomes		2SDT (25%) 4MDT (50%) 1MFT (12.5%)  Total 7 (87.5%)	3MFT (33.3%)  Total 3 (33.3%)
Poor Outcomes		1MDT (12.5%)  Total 1 (12.5%)	2MFT (22.2%) 1SDT (11.1%)  Total 3 (33.3%)

**9.4. Were There Direct Relationships Between Team Effectiveness And Success Outcomes?**

Table 9.8. shows that satisfactory technical outcomes were attained irrespective of team effectiveness, since the majority of teams achieved satisfactory technical outcomes.

Table 9.8 The Significance Of Team Effectiveness For Technical Outcomes

Team Effectiveness	Satisfactory Technical Outcomes	Unsatisfactory technical Outcomes
Effective teams	14 (93%)	1 (7%)
Teams with mixed effectiveness ratings	9 (100%)	0 (0%)
Total	23 (96%)	1 (4%)

Table 9.9. shows that the relationship between commercial outcomes and team effectiveness is unclear or non-significant. Thirty-three percent of both effective teams and teams with mixed effectiveness ratings were associated with good commercial outcomes. Furthermore, only 11% of teams with mixed effectiveness ratings were associated with

poor commercial outcomes, thereby suggesting that team effectiveness has little influence on commercial project outcomes.

Table 9.9. The Significance Of Team Effectiveness For Commercial Outcomes

Team Effectiveness	Good Commercial Outcomes	Moderate Commercial Success	Poor Commercial Outcomes	No Commercial Outcomes
Effective teams	5 (33%)	5 (33%)	3 (20%)	2 (13%)
Teams with mixed effectiveness ratings	3 (33%)	5 (56%)	1 (11%)	0 (0%)
	8 (33%)	10 (42%)	4 (17%)	2 (8%)

Table 9.9 suggested that team effectiveness is not more typical of projects with good commercial outcomes than less successful projects. This was surprising in view of findings that the majority of the sample regarded the team as being very important for project success (Section 9.5). However, further analysis in Table 9.10, which classifies projects according to different types of markets, reveals a clear relationship between team effectiveness and the success outcomes of client-funded projects, not also directed at open markets. All commercially successful client-funded innovative projects were developed by effective teams.

Only 33.3% of projects dependent on open markets achieved ‘good’ commercial outcomes. Surprisingly none of the projects that were partially or fully client-funded but also directed at other markets, achieved ‘good’ commercial outcomes, although all achieved moderate commercial outcomes due to the funding received.



Table 9.10. Influence Of Team Effectiveness On Commercial Outcomes In Different Markets

Abbreviations:

*MFT is a Multi-functional team; SDT is a Single-disciplinary team; MDT is a Multi-disciplinary team.*

*Note 1: Two companies are excluded from this Table, Analytik's (project 2) which was abandoned pre-commercialisation and Filtratec's (project 2) which had not been fully commercially developed at the time of interview.*

*Note 2: Percentages are given for markets*

Commercial Outcomes	Entirely client-funded	Partially or fully funded & also aimed at open markets	Dependant on open markets
Good Outcomes	5 (100%) effective teams		3 (33.3%) teams with mixed ratings
Moderate Outcomes		4 (50%) effective teams 3 (37.5%) teams with mixed ratings	1 (11.1%) effective team 2 (22.2%) teams with mixed ratings
Poor Outcomes		1(12.5%) effective team	2 (22.2%) effective teams 1(11.1%) team with mixed ratings

An analysis of the commercial impacts of the team approach adopted for different markets suggests that when markets are guaranteed, team effectiveness may be important, whereas when projects are wholly or partially aimed at open markets then other factors affect both team operations and outcomes. Although, the sample was too small to perform a *Chi-square* test of the statistical significance of relationships between success outcomes, team approaches, team effectiveness and markets, Section 9.6. explores in-depth case studies to elucidate the significance of team effectiveness for project outcomes in different types of markets.

### **9.5. The Impact Of The Team On Project Success**

Table 9.11. demonstrates that 84% of the sample regarded the team as very important for project outcomes, irrespective of their project's commercial success. A further 12% of the project teams regarded the team as a necessary approach to innovative project development even if it caused problems. Only 1 company team did not regard the team as important for commercial and technical project outcomes.

Table 9.11. Perceptions Of Importance Of Team For Technical And Commercial Outcomes

NB. Percentages are given for the total sample

Importance of team for project outcomes	Good Commercial Outcomes	Moderate Commercial Outcomes	Poor Commercial Outcomes	Total
Very important for project outcomes	Innovconsult, Filtratec (1), Pollution Control Engineering, Analytik (1), Sludge Treatment Systems	Cheminstrum, Filtratec (2), Datalog, CWT Engineering, WQU, Water Services, Longman (1 & 2), Filtratec (2) Biogentech	Greenwater, R&D Laboratories, Analytik (2), Engineering Projects, Robinson Engineering	
Total	5 (21%)	10 (42%)	5 (21%)	20 (84%)
A necessary approach even if team is source of problems	EMS, Wasserpur	Sensorval		
Total	2 (8%)	1(4%)		3 (12%)
Team of little consequence for project outcomes	Systems Engineering			
Total	1 (4%)			1 (4%)

The following case reports illustrate the importance of the team for project development and success outcomes.

**Robinson Engineering,**

The Technology Development Management pointed out that if a team is built with inputs from development, engineering, sales and from the client, the path of the technology development is eased. He added that ‘without a team approach you get internal barriers created by people who would create no problems if they were given some responsibilities and kept informed throughout the process. You can get people enthusiastic about things if they are involved and when responsibility is shared down the hierarchy’. This team approach was important despite the lack of commercial success for the sewage treatment project development which was under discussion.

**Cheminstrum**

The Finance Director said that the key to success was overall company confidence in the particular strengths of individual team members, including scientific expertise, commitment to the project team, enthusiasm, an excellent work ethic, the desire to succeed and self motivation. The Finance Director thought that the team approach ‘was essential to turning an essential concept into a marketable product’. However, sales had not yet yielded a full Return On Investment and technical outcomes could have been enhanced by greater internal resources which they lacked as a small company. Poor availability of resources may also have accounted for the failure to plan the development of derivative projects from the original innovative work.



Only one company team did not regard the team approach as very important for project technical and commercial outcomes. However, the team from Systems Engineering was regarded as important for ideas generation, a view also supported by Innovconsult and Wasserpur.

#### **Systems Engineering**

The Technical Director of described the team approach as the ‘fun part of the work’, but successes were more attributable to his role as the project manager. He did not think that the design quality emerged from a team effort because any one person was sufficiently competent to design a good product alone and the clients would be happy with any individual design. However, he thought that the team approach was important to talk through contracts in order to generate good ideas.

### ***9.6. The Team’s Influence On Success***

It is important to explore the case reports in greater depth to consider the significance of the team for project development and success outcomes for two reasons:

**First**, the results suggest that team effectiveness may be of greater importance for client-funded project outcomes as distinct to projects directed at open markets. Although commercially successful projects were not wholly associated with an effective team approach (Table 9.10), all of the successful client-funded projects had been developed by an effective team approach in companies including, Innovconsult, Systems Engineering, Filtratec (project 1), Sludge Treatment Systems and Pollution Control Engineering. This section explores the greater significance of team effectiveness for fully client-funded projects by comparison with projects directed at open markets.

In client-funded projects, it is arguable that market uncertainties are largely removed from the concern of the team. The case reports discussed in Section 9.6.1. suggest that the commercial success of client-funded projects depends on effective integrated team approaches, effective project management and the client relationship. The cases also suggest that the Project Manager’s role is instrumental to the achievement of effectiveness in these areas.

**Second**, the results suggest that multi-functional teams are most typically adopted for projects directed at open markets and characterise all successful projects of this kind. A multi-functional team approach may be more important than other team approaches, both single and multi-disciplinary, and team effectiveness for the success of innovative developments directed at open markets. Innovative projects aimed at open markets have a

greater challenge in addressing the needs of multiple customers in conditions of greater market uncertainty which creates a requisite for more complementary assets, including finance, marketing and manufacturing assets (See Teece, 1986).

#### **9.6.1. Significance Of Team Effectiveness For Commercial Success Of Client-Funded Projects**

Although there was a diversity in the team approaches adopted to client-funded project developments, it was noticeable that all successful projects, with the exception of the Systems Engineering, were developed by an integrated team, either a multi-disciplinary or multi-functional team approach. The following case reports clarify the importance of the following for the commercial success of client-funded projects: integrated team approaches and the effectiveness of the team, project management and client relationship.

##### **Innovconsult**

The successful project under discussion was concerned with the exploitation of a technology which had been failing both technically and commercially. Innovconsult transformed the technology into a growing twenty million dollar business for their clients. Innovconsult attributed both the source of their innovative ideas and their effectiveness in rapid product development to inter-disciplinary team working, early interdisciplinary planning, concurrent working and to the role of project manager. The Project Manager emphasised that 'The intellectual rigour behind the planning and having the right people is more important than project management technologies'.

##### **Pollution Control Engineering**

This successful project was developed by an effective multi-disciplinary team. Like Innovconsult, the Project Manager believed that personality and communication skills were so important for a successful team that staff recruitment is a priority within the organisation. The Project Manager's role was important for success outcomes because it is difficult to bring together 'the right people with the right skill at the right time to the job'. They attempted to enhance their project management skills by conducting a kind of post-mortem on projects, when they considered if the project could have been carried out more effectively, more cheaply and more in line with manufacturing and maintainability concerns. Successful project management is very much a person-oriented thing and requires continual assessment of the reliability and capability of the people and companies involved.



### **Sludge Treatment Systems**

The Project Manager regarded the organisation's decision to set up team approaches formally as very effective. Greater liaison between designers and construction engineers helped them to design to specification and to budget, with a greater awareness of design problems and construction concerns. Typically construction engineers were blamed for excessive project costs which is not entirely justified since they build from an approved design. Greater liaison between designers and engineers has helped designers to become aware of resource management issues and prevent problems from arising in the first place.

The importance of the client relationship is implicit in the case reports on Innovconsult, Filtratec (project 1) and Sludge Treatment Systems. The client relationship was also important in Systems Engineering where it was a source of problems, such as delays in securing client approval of plans and inadequate client attention to early specifications.

### **Pollution Control Engineering**

The Project Manager of also pointed to the importance of the client relationship which was enhanced by openness and co-operation. He said 'You have got to be honest with the client about things which affect the overall project otherwise you lose trust. They are relying on you to carry out the project on time, on schedule and to budget'. This attitude and the value attributed to working relationships outside the organisation has helped them to win repeat business and maintain a long-term relationship with the client. He pointed out that 'It is the small things on a project that make it run fairly easy, such as knowing your client and their attitude to certain things, the way they run their organisation which may be totally different to the way you run your organisation'. He pointed out that smooth team and project operations are enhanced by the capability of the supplier or contractor to adapt to the way the clients run their organisations.

#### **9.6.2. Limitations Of Effective Successful Teams**

Although effective integrated team approaches, project management and client relationships may be directly linked to the commercial success outcomes of client-funded projects, the team role is usually project limited and project success outcomes do not necessarily secure the survival of the company which is influenced by market vicissitudes.



### **Sludge Treatment Systems (STS)**

With the take-over of by a water utility, STS had hoped that the acquiring company, which had been their main customer, would provide new business for the company. However, its priorities changed and STS found that their markets 'dried up'. This together with the company's failure to diversify, caused the company to dwindle from medium-size to a point where it only employed five people and faced liquidation. The Project Manager's expectation that there would be an explosion of investment in sludge treatment with the enforcement of environmental legislation was, unfortunately, too late to save STS.

Although multi-disciplinary team approaches helped this company achieve good technical outcomes for client-led projects, their importance for other success outcomes was clearly limited in view of the company's problems. While team approaches can be very important for project outcomes, their wider value for the organisation depends on how well teams are empowered to address organisational problems and whether they are harnessed as a tool to implement the strategic vision of the organisation. In this company the team approach appeared to be project-limited and too weak at an organisational level to withstand the negative blows of organisational change associated with acquisition. However, the technical and commercial outcomes for the project under discussion had been very satisfactory.

#### **9.6.3. Significance Of Multi-Functional Teams For Commercial Success In Open Markets**

Although all of the commercially successful projects directed at open markets were developed by multi-functional teams, they were all given mixed effectiveness ratings by team members in EMS, Wasserpur and Analytik (project 1). The mixed effectiveness ratings were mainly attributable to difficulties in team interactions and with inter-functional integration. Chapter 8 supports this, finding that multi-functional teams with mixed ratings in team effectiveness experienced the greatest number of problems with both team interaction and task management. The multi-functional team requires members to work with staff who have different expertise and values and sometimes to manage staff in areas where they have no expertise. The following cases show that despite team and project development problems and mixed views on team effectiveness, projects can be technically and commercially successful. Although, the team approach was regarded as very important for project success outcomes, it is also important to consider other influences on commercial success outcomes of projects directed at open markets. The marketing strength of EMS, Wasserpur and Analytik is particularly noteworthy.



## **Wasserpur**

Four staff representing development and marketing functions commented on the significance of their team and effectiveness for commercial success. The minor innovation product which tested water purity was highly successful commercially in terms of entering new geographical markets and exceeding the sales forecasts in the first year by 25% or more. This product was developed in eighteen months by a multi-functional based team of chemical and mechanical engineers, draughtsmen, marketing and sales staff, lab. staff and senior management staff from both Wasserpur and its parent company, as well as involving external design consultants and suppliers.

Thus despite a number of problems, such as technical, marketing, project management, team problems and mixed views on team effectiveness, the project was a commercial success. The technical development problems were quite minor in importance for project outcomes. The product had been developed with few technical problems and was of high quality and performance and met client satisfaction criteria. There were so few modifications required within the first two years of sales that in effect they 'got it right the first time'. During the course of the project development, three team members mentioned that there was a problem with obtaining basic resources and equipment. However, the Project Manager did not think their resources were too limited by this. Two team members mentioned that during the project development they became aware of new legislation which impacted on their project. There was insufficient time to redesign for compatibility, but their latest product version will meet legislative requirements. The Project Manager pointed out that they aim to have as few technical problems as possible, partly because of their engineering pride but also because they would have to carry out any required modifications. This would mean more work, less efficiency and less profit eventually with all its implications. He thought that most of the team members were proud of the product, which had been very good for the reputation and status of the department.

The Marketing Director was the only team member to comment on marketing problems. He mentioned problems associated with competing in uncertain markets during an economic recession. The company had also decided not to patent and this may have negative repercussions by encouraging imitative competitor activity. However, this may be no problem, since the entry costs to these markets are high relative to the volume market.



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There were a number of project management problems, including delays associated with subcontracting the product design work to an external design consultancy. Further delays were caused by design specification changes when marketing pressurised development to develop a high quality but low cost product, requests which R&D regarded as 'impossible' or 'stupid'. The delays incurred led to a slower than expected development time, even though the product development time was quite good and they met deadlines for the product launch. The Project Manager said that he did not see how this slow business could be improved 'unless you're extremely lucky and it all drops into place first time. It is likely to be a bit iterative and this certainly was'.

The Project Manager regarded the development approach as 'pretty effective' although 'it probably seemed like organised chaos at times'. He emphasised the importance of speed in project management 'You've really got to get things moving pretty damn quick otherwise you're just not going to get there'.

However, only half of the team members contacted rated the team as effective. The Project Manager attributed this to both misunderstandings in communication and some personal problems which led to shortcomings. Each of the team members mentioned different problems of varying importance which affected team effectiveness, such as:

- poor resources of time, staff and money for the project;
- too few staff leading to unfair work loads and over-stressed, over worked staff;
- conflicting demands between the technical service role and the new project;
- weak leadership, unclear goals and briefing, unclear procedures for operations;
- poor communication within the team and uncooperative members;
- poor sharing of responsibilities, low acceptance of accountability for results and poor organisational rewards for team work.

Although there were mixed views on the team's effectiveness the Project Manager thought that the multi-functional team approach was valuable for the project success. The commercial success of the product was helped by appropriate product timing for the market and low competition. associated with the product innovation. However, all team members regarded the team approach as essential or making a significant contribution to the project success.

## **Analytik**

The importance of the multi-functional team approach to the development of a minor innovation sensor product (project 1) was clarified by three team members. The company had benefited as a result of environmental legislation which was creating a need for new environmental monitoring products which could detect new levels of pollutants and establish whether new legislative limits were being met.



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Recent organisational changes over to the adoption of multi-functional teams reflected an awareness of the relation of profits to fast market time. In competitive established markets it may be more profitable to get a product with less functionality out to market faster than to delay entry with a cheaper or more innovative product. The Design and Development Manager said 'In the past it was felt that whatever we produced had to be right, even if it meant delaying entry to the market. I think that the best is the enemy of the good. These days we are more likely to say the product is good enough... and bring out a Mark II as quickly as we can or a III or IV'.

By November 1995 the product was selling well, a number of variant products were being developed. There were plans to reduce costs by investing in new manufacturing technology. This success was achieved despite technical problems with changing design specifications, some difficulties with obtaining basic resources and equipment, conflicting demands between different project responsibilities and the view of some team members that there was poor timing in the project development. Although the manager regarded the team as effective, a different situation was portrayed by other members who only rated the team's effectiveness as average at best and beset by many problems, such as:

- too few members;
- personal problems, such as poor motivation and depression;
- poor communication within the team and with the rest of the organisation;
- unclear goals, briefings and procedures for operations;
- poor tolerance of disagreements;
- low trust, particularly between staff with different expertise ;
- poor senior management support;
- poor organisation generally;
- poor organisational rewards for team work, such as salary, promotion and recognition.

## EMS

Two team members clarified the importance of the team approach for the success of a minor innovative product development project. This marketing-led development project was a technical success despite some minor technical problems and a Mark II of the product was pending. It had been very commercially successful which was as expected since it was an established product launched onto established markets where the company had a strong awareness of the customer's requirements and where the company's marketing capability could be exploited without requiring any significant market risk. The product sales met and exceeded targets in most markets and where it performed less well it was a result of inadequate sales distribution channels rather than the product's quality, functionality, price or the team approach. However, it has been very successful commercially and their competitors are concerned that they have captured 80% of the market within two years of entering the market.



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The multi-functional team approach appeared to be the source of the few problems experienced on this development project, such as slower than expected development time. The Marketing Director blamed this delay on the R&D staff who were not as commercially minded as they should be. He found that deadlines tended to be missed by R&D, probably as a result of poor time estimations in development and R&D perfectionism.' However, he admitted that R&D staff were pressurised marketing to make or accept unrealistic estimations of project development time.

By contrast to the Marketing Director, the Product Manager regarded the team approach as an effective approach which could not be easily improved since the development team met the requirements defined by the marketing team and produced a good product which sells well. This was despite problems, such as too few members and changes in team membership which led to a shortage of expertise and unfairness in work loads. Other problems in the team included a low acceptance of accountability for results and conflicting demands between projects worked on by team members. Despite mixed views on team effectiveness, the Product Manager pointed out that 'the project would not have worked without the team approach'.

#### **9.6.4. Significance Of The Team For Projects With Moderate Commercial Success**

The 10 projects considered here were all ultimately launched on open markets, although seven projects were either partially or fully funded by a client or internally. Although projects developed by Longman (projects 1 & 2), Powerengineering, Water Quality Utilities, CWT Engineering, Water Services, Biogentech, Sensorval, Cheminstrum and Filtratec (project 2) have achieved some commercial outcomes, the commercialisation of these projects is ongoing and outcomes are yet to be fully determined.

In the cases of Longman (project 1), Water Quality Utilities, Powerengineering, CWT Engineering, Water Services and Datalog, the teams had a technical development remit and therefore commercial success outcomes were not clearly related to the team operations and effectiveness. Water Quality Utilities, Powerengineering, CWT Engineering, and Datalog were all rated as effective, which may suggest that team effectiveness is more easily achieved when teams are focused on technical objectives, unlike team approaches which have both technical and commercial objectives. Team effectiveness may be associated with outcomes which fall within the control of the team.



### **The Attitude of Effective Single-Disciplinary and Multi-Disciplinary Technical Teams to Commercial Project Outcomes**

**Water Quality Utilities** expected commercial outcomes to be achieved by another company, since the project was an internal technology project which was successful in terms of improving company operations and meeting environmental legislation requirements.

The team at **Powerengineering** expected to continue to develop their innovative work within client-funded contracts secured by sales staff.

**CWT Engineering** expected sales to attend to the market demand for a partially client-funded project. The Process Engineer involved did not expect the pollution control project to be a great money spinner, since pollution control imposed costs on organisations rather than contributing to profits.

Although the single-disciplinary **Datalog** team had a technical remit, they became increasingly concerned about problems with other functional groups, including purchasing, marketing and senior management which impacted negatively on the project development process and commercial outcomes. These functional groups were always viewed as external to the team.

Teams with a technical development remit may find it easier to achieve effectiveness than teams with both commercial and technical remits because people find it easier to develop group cohesiveness, a shared purpose and work with those from their own thought-worlds (Ancona and Caldwell, 1992). Furthermore, unless products are very technologically innovative the goals of technical teams are more controllable. However, teams with technical goals were not always rated as effective, as the cases of Water Services and Longman Engineering demonstrate. However, it appears that these teams had mixed ratings of team effectiveness because project associates became increasingly concerned with commercial outcomes.

#### **Water Services**

The **Water Services** team worked with teams from both a university organisation and a company to support the commercialisation of an internal technology project. Apart from the Technical Director, the team regarded the team approach as effective and were satisfied with the technical success of the project and the benefit to internal operations. His mixed feelings about the effectiveness of the team approach were partially attributable to problems with inter-company relationships which were related to different priorities and commercial orientations. However, the main problem related to commercial inexperience, even though Water Services did not intend to transform the project into a commercial product themselves. Their role was to liaise between the organisations involved and this represented a new learning experience.



### **Longman Engineering (Project 1)**

This partially client-funded geographical information system (GIS) application was developed by several co-ordinated single-disciplinary teams with a technical remit. As a result of the company's investment in the project, they hoped to capitalise on the intellectual property and use it to diversify into new markets since their traditional markets had shrunk. The team was not rated as effective because they were on a project management learning curve, using a new project management methodology on a project in markets where they lacked experience. Organisational difficulties led to a greater use of multi-functional team approaches and an increased market orientation, where the teams became obliged to measure their success in terms of generating tomorrow's work and not just task completion. One team member said 'As it was before, the project team would measure their success according to whether they completed the task. Commercially that is disastrous because the project is history, the future is sales and marketing and the customer is today. Once you have got a customer for the project, that is history'. In this context, the team could not be regarded as effective when it was recognised that there was a limited market potential for the project technology.

The case reports on the technical teams above suggest that commercial outcomes could be improved by a more multi-functional team approach from the outset despite the problems and limitations discussed in Chapter 8. The achievements of teams are limited to members' expertise, organisational power and remit. Ratings of team effectiveness appear to be linked to the scope of the team's remit.

When the team approach is more multi-functional, then perceptions of team effectiveness are linked to issues associated with both technical and commercial outcomes, where the team has responsibilities. This might suggest that ratings of multi-functional team effectiveness would be more directly linked to commercial outcomes, than ratings of technical single and multi-disciplinary teams.

The cases of commercially successful multi-functional teams show that success may be achieved despite poor effectiveness ratings which are caused by team interaction and task management problems. The wider remit of multi-functional teams means that a wider set of issues are brought under the control and responsibility of the team(s) or team members. This is evident from cases of multi-functional teams which achieve moderate success outcomes as well as good or poor outcomes. A selection of case reports on multi-functional teams which achieved moderate outcomes illustrates this including Sensorval, Cheminstrum, Longman (project 2), Biogentech, (project 2) and Filtratec (project 2).



### **Filtratec (Project 2)**

This was a small company-wide effective multi-functional team approach. Team members mentioned concerns with establishing the technical viability of the project, securing patents, competing in uncertain markets as well as problems with resourcing team work on the project which was also associated with heavy workloads. However, the team was regarded as 'critical for both the technical and commercial outcomes' and the team had successfully achieved the inter-company alliances necessary to bring the project forward to commercialisation.

### **Biogentech**

There were mixed views on the effectiveness of this team approach, largely as a result of the learning experience associated with the development of the major innovation. Although establishing technical viability was an important initial concern, problems with the unpredictability of biological systems were resolved during development. There were other problems associated with the lack of proximity between the development and validation teams involved with the project. Further problems associated with the shareholders in the Biogentech joint-venture were to be resolved with a majority shareholder buyout.

They decided to deploy resources to develop a less innovative product concurrently, which would prepare the market for the more innovative version. The Managing Director said 'we realised there was the potential to put in place a shorter term product to get to the market quicker which would develop a market for us, which we could then supersede ourselves'. Progress was continuing with the commercial exploitation of the technology and the majority shareholder had proved to be a good customer. In addition, they had licensed the technology to a US company which allowed the company to break even. They anticipated making profits in their 5th year of development.

### **Cheminstrum**

The effective team was a small company-wide multi-functional team approach to developing a project which had applications in both environmental and pharmaceutical sectors. This team was regarded as effective despite numerous team and project development problems. The project was commercially successful both in terms of profit and meeting client satisfaction. However, sales were less than they hoped and they have not broken even yet. Although this could be attributed to the recession, in reality they thought that perhaps they had overestimated the market potential and failed to consider the development of derivative products early enough. The company experienced greater difficulties with trying to market products in regulation-led environmental markets where market entry depended on the enforcement of regulation, than pharmaceutical markets where their product could offer commercial advantage to their clients. This led to a concentration on pharmaceutical markets by Cheminstrum.



### **Sensorval**

The multi-functional team approach which involved the co-ordination of three company teams with the development of a major innovation in environmental testing was rated as ineffective due to team problems, even though the project manager ultimately pulled the teams together and attained satisfactory technical outcomes.

The R&D Director as project manager mentioned that there had been lots of problems, the biggest being associated with the failure of one of the partner teams to perform to specification on time and address technical quality problems. However, she had probably underestimated some of the development problems associated with a relatively unproved technology. There were other technical problems associated with poor design compatibility between the technological development efforts of each company and poor in-company quality control. These problems, although ultimately resolved, slowed down the market launch of the product, although it was still developed within a year very cheaply.

The R&D Director had expected to cover R&D costs within the first year of trading and she anticipated that this investment would prove worthwhile for both expected profits and for the family of future generation products which Sensorval hoped to capitalise on for the next decade. She described it as 'an investment in the future'. Unfortunately, four months after the product was launched, the company was embroiled in litigation initiated by a US company which claimed that their patent had been infringed. This was a complicated situation because the patents were distinct; the competitor US patent was merely a concept without any development details, unlike the Sensorval's UK patent. The R&D Director said it was analogous to the difference between the concept of a horseless carriage and the practical details of how to design and manufacture cars. Unfortunately, it will take three years to resolve the patent contest and meantime Sensorval is unable to sell via distribution companies since this would drag them into the litigation proceedings. Although an attempt has been made to negotiate an agreement with the US company in order to permit the implementation of the selling strategy, this has been rejected by the US company. Sales have been significantly slowed, although excluding legal costs, Sensorval had covered development costs.

#### **9.6.5. Significance Of The Team For Commercially Unsuccessful Projects**

Commercially unsuccessful innovative products and processes show that factors other than the team approach and team effectiveness need to be considered in explanations of commercial outcomes in open markets. Four of these project teams including R&D labs, Greenwater, Robinson Engineering and Analytik (project 2), had been rated as effective despite the fact that no commercial success was delivered.

Analytik (project 2) was never commercially developed as a result of technical uncertainties associated with unproved technologies in addition to pressures on staff resources. Despite team effectiveness in this case the project was abandoned because technological uncertainties were too great. The lack of commercial success for other projects was attributable to market uncertainties including Engineering Projects which had



mixed effectiveness ratings. Market uncertainties in these cases were not primarily associated with the economic climate, organisational activities or new technologies but with government failure to enforce EU environmental legislation. Despite team effectiveness the project may be commercially unsuccessful because of the uncertain nature of markets which are dependent on the enforcement of environmental legislation (in the cases of R&D labs, Robinson Engineering and Engineering Projects) or forecasting new markets as a result of concerns with water conservation and associated water costs (in the case of Greenwater).

The problem with innovation in the environmental area is that it is often highly risky if sales are contingent on legislation enforcement. This is because environmental monitoring and pollution control products do not usually make a contribution to either cost-reductions or profits of the purchasing company. The least successful projects depended on the enforcement of environmental legislation in the US, EU or UK as the stimulus to market creation. Highly commercially successful projects tended to address existing markets which were supported by enforced legislation or customer interest. Problems with markets dependant on the enforcement of environmental legislation are illustrated in the following case reports, which highlight the limitations of teams in the context of such market uncertainties.

#### **R&D Laboratories Ltd**

This small research and development company, adopted 'a pro-active stance' with development work in the environmental safety area which was based on the expectation that environmental legislation would be enforced by government. However, as an R&D company they relied almost totally on their bigger industrial partner to address the marketing and manufacturing project requirements and instead concentrated on costly patenting activities. This liaison with a larger enterprise was originally perceived to be advantageous for this company because it provided access to a large customer base and an international market for their products.

Problems arose with the late discovery that their industrial partner had not set up a manufacturing contract for their products and had developed 'cold feet' about both the chemicals used in the products and the prices charged and wanted to wait to see how the markets developed. The industrial partner had not invested significant time and financial resources into the project and this enabled them to pull away without significant wounds from a joint venture which by contrast may put R&D Laboratories into liquidation.



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Furthermore, there was a concern that in the present recession the government was failing to enforce environmental legislation because the enforcement of this legislation would have a negative economic impact on industry. This explained the partner's cold feet. More generally, the company suffered from the typical problems of a small R&D company with little marketing capability, operating within uncertain markets and struggling to operate in a recessionary climate, where they experienced difficulties in setting up collaborative ventures or winning government funding.

At a second interview, the company had laid off all the staff, and the Directors were trying to salvage some of the earlier promise of the business within the options of partnerships or a sell-out of the patents to an American company. The Finance Director said that 'the market was only scratched' and the Technical Director described the situation as 'near disaster'. Despite the lack of commercial success the products were technically successful and were protected by international patents without an overspend on allocated R&D budgets. Furthermore, the effectiveness of the team had been very high and staff were described as highly motivated and fighting valiantly to the end, although there were some sour grapes when staff were ultimately laid off without full pay. Despite an initial strong sense of team effectiveness and satisfaction, the single-disciplinary technical team did not and was not empowered to address these problems associated with inter-company relationships and market uncertainties.

### **Robinson Engineering**

The Technical Director had been aware of market uncertainties during the development of a sewage treatment product, which were associated with government failure to enforce the environmental legislation and create a market requirement. There was a significant change of attitude in their potential clients who were not prepared to purchase beyond what is required by legislation. The Technology Development Manager said 'For the client, putting in an environmental plant usually means additional cost. They will only do it if they are forced to do it'.

They had had no sales and even their development partner would not commit to a purchase, despite their own considerable investment. One team member said that the 'future appears bleak' and another summarised the situation and said that 'At the time of the project development, optimism for success was high, although recent changes in legislation and market attitudes may prove to be excessively damaging and the high development expenditure may not be returned'. However, they hoped that there would be a niche market for the technology and they were prepared to wait for the right market timing. Management were philosophical about this situation, although they were 'not deliriously happy'. Their wry perspective was that without such risk-taking they were in danger of not generating any business and losing the competitive edge in increasingly competitive markets. Although technically the project was a success and the team approach was both effective and an essential part of this development, the project was effectively shelved.



### **Engineering Projects**

There were mixed views on the effectiveness of the team with some blame attributed to the R&D team who were managed by marketing staff. Time was lost at the R&D stage because of the uncertainty of the inventive work which caused deadlines to drift. At the time of the first interview, the Marketing Director did not believe that slow development time was a problem because the markets which depended on the enforcement of EU legislation on safety were not ready for the product. However, slow development time was revealed to be an issue during a follow up interview, because the company failed to meet a window of opportunity as a result of technical concerns with product quality. This opportunity closed following the privatisation of British Coal and the privatised organisations were reluctant to pay the high price for the safety product when current legislation did not demand it. The product was twice the price of competitor products, although this difference would be reduced if users adopted proper safety precautions since more than one competitor product would be needed to provide the same levels of safety. Although efforts were made to reduce the price of the product, they could only produce it more cheaply if there was a market for high product volumes.

Poor commercial success, as indicated by no sales, was primarily attributed to new and uncertain markets dependent on the enforcement of EU safety legislation. Other reasons for poor success include technical quality issues, problems with the R&D interface and delays waiting for a license from the Department of Trade and Industry. These problems led to slow development timing and the failure to meet the opportunity to sell an innovative, technically superb product which offers a level of safety unrivalled by competitor products but at an unattractively high price.

### **9.7. Summary**

Although the sample was too small to test for the statistical significance of relationships between success outcomes and both different team approaches and team effectiveness, the findings suggest that neither team effectiveness nor the adoption of specific team approaches - single-disciplinary, multi-disciplinary or multi-functional - can directly account for the technical and commercial outcomes of projects in general. Both technical and commercial success outcomes were associated with all team approaches and with differential ratings of team effectiveness.

However, it was surprising to find no clear relationships between team approaches, their effectiveness and success outcomes, since the majority of teams (96%) regarded the team approach as necessary to the development of innovative products and processes and responsible for positive project outcomes. This prompted further analysis which showed that all of the successful client-funded projects were developed by teams rated as effective, whereas ratings of team effectiveness were more varied when projects were directed at open markets, even when there was a client involved. Further in-depth analysis of case studies suggested that when projects are fully client-funded, market uncertainties are



largely removed from the team and the key influences on project commercial success include integrated team approaches and the effectiveness of the team, project management and client relationship. For client-funded projects, the Project Manager's role is instrumental to the achievement of an effective integrated team and satisfactory client relationship which helps the team to achieve the commercial success.

It appeared that a multi-functional team approach was important for innovative development products launched on open markets. The multi-functional team was the most typical team approach adopted and it dominated the projects associated with commercial success in open markets. In open markets, the success of innovative products and processes depends to a greater extent on the company's access to complementary assets, such as marketing and manufacturing capabilities (See Teece 1986). Success also depended on the importance of legislation and its enforcement. The least successful projects depended on the enforcement of environmental legislation in the US, EU or UK as the stimulus to market creation whereas more successful projects operated in more certain markets which were supported by enforced legislation or customer interest.

The chapter attempted to explore the influence of team approaches and their effectiveness on commercial success outcomes. Team effectiveness may be more directly related to the commercial success outcomes of client-funded projects than those of products targeted at open markets. Yet one would expect that team effectiveness is important for the development of innovative product and processes directed at open markets and indeed this view was shared by the majority of teams.

The influence of team effectiveness on success outcomes may be explained by considering how team members rate their team's effectiveness. **First**, the findings suggest that teams which pursue technical goals alone may rate themselves as effective, even if commercial outcomes are poor or moderate, since the commercial outcomes are not regarded as their responsibility. Team member ratings of team effectiveness may be therefore limited to the control and remit of the team.

**Second**, Chapter 8 has shown that teams with both technical and commercial goals (multi-functional teams) were less frequently rated as effective than teams with a technical remit (single and multi-disciplinary teams), even if moderate or good commercial outcomes were achieved by the former. This may be because of the additional problems associated with multi-functional teamworking and greater market pressures. The wider remit of multi-



functional teams means that a wider set of issues are brought under the control and responsibility of the team which may help them to achieve commercial success, even when the team is not rated as effective by team members.

**Third**, Chapter 8 has provided further insights into how team members rate the effectiveness of their team. The findings show that teams with greater problems are more likely to give mixed ratings of team effectiveness, even if these problems are later solved. The challenges of developing and marketing more innovative products and processes may require more inter-company liaison, organisational learning and more innovative management approaches. This may give rise to poorer ratings of team effectiveness without predicting poor technical and commercial success outcomes. Perceptions of team effectiveness may be more likely to accompany less innovative, more certain project developments developed by technical teams operating in circumstances where either market pressures are largely irrelevant or where they are removed from the responsibility of the team..

It appears that team effectiveness is important in all types of markets, although its influence on success in open, uncertain markets is more complex, since team effectiveness ratings are influenced by the team remit and goals, the impact of multi-functional teamworking and the greater number of problems associated with innovation. All three possible explanations above point to the greater challenges posed by developing more innovative products and processes directed at uncertain markets requiring more multi-functional team approaches. In this situation, team effectiveness is more difficult to achieve, although it may not be the key determinant of commercial success which also depends on company access to complementary assets and government enforcement of legislation in markets dependant on this. By contrast, the influences of team and project management effectiveness and the client relationship is of greater importance to the success of client-funded innovative products and processes, where market uncertainties are removed.

# Chapter 10 Discussion Of Main Findings

## ***10.1. Introduction***

This study assists the search for new models of innovation management which have been deemed necessary to address the competitive challenges of higher productivity, faster product cycles, higher quality and lower costs in an increasingly internationalised industry, transformed by technological change (See Souder and Sherman, 1994). The main aim was to evaluate multi-functional teams which have been heralded both as an innovative approach to the development of innovative products and processes and the solution to the problems represented by sequential approaches to innovation management which have reflected linear views of the innovation process. Sections 10.2-10.4 considers findings on the influence of firm size, level of project innovation and the nature of markets on the operations of multi-functional and other team approaches to innovation. Section 10.5-10.6 explores and evaluates research findings on organisational team approaches to innovation. Furthermore, Section 10.7. discusses the impacts of multi-functional and other team approaches on the technical and commercial outcomes of innovative products and processes in environmental organisations.

## ***10.2. Firm Size***

The literature pointed to the appropriateness of multi-functional teams to large-sized company operations, although this research was limited to automobile and consumer electronics industries (Durand, 1995). There is a scarcity of information which clarifies the appropriateness of multi-functional teams to medium-sized and small-sized firms and their appropriateness to other industrial sectors. The results show that multi-functional teams were appropriate to companies of all sizes, including small-sized and medium-sized companies which have not been researched before. However, multi-functional teams in small firms were distinguished from medium-sized and large-sized firms in two key ways.

**First**, unsurprisingly the multi-functional team in the small firm was less formally organised since the small firm is typically characterised by informality (Rothwell, 1989). However, project teams in the small firm were more formally organised when they were involved with inter-company alliances.

**Second**, the small company multi-functional team was characterised by staff multi-tasking in both their own and other areas of expertise, often as a result of pressure on resources and



a scarcity of expertise. Several researchers, including the author, have confirmed that the small firm is limited by scarce resources and frequently experiences recruitment and retention problems (Rothwell, 1989; Caird, 1992). By contrast medium-sized and large-sized companies tended to have expert membership in teams and multi-tasking was actively discouraged in at least one company, since it was regarded as a barrier to inter-functional integration. When expertise is available, it is arguably inappropriate and counter-productive for team members to multi-task outside their established expertise, unless the company has scarce resources which would make multi-tasking necessary.

The small company multi-functional team was different to the multi-functional team as recommended by Takeuchi and Nonaka which has formal as well as informal elements (Takeuchi and Nonaka, 1986). Their recommendations for the implementation of the multi-functional team included a rather formal organisation approach associated with overlapping the development phases of innovative products and processes (Section 2.2.2.3). Recommendations also included subtly controlling projects by both selecting the 'right people' for the team and rewarding the team not the individuals and so on (*ibid.*, 1986). The results of this research suggest that the small firm multi-functional team reflected small firm characteristics of an entrepreneurial environment to a greater extent than such Japanese-inspired management practices (See Section 2.4).

It is likely that the multi-functional team in the small firm may benefit from the more formal aspects of organisation recommended by multi-functional team protagonists, since there is evidence that inter-functional integration can be a problem for the small firm (See Livesay *et al.*, 1989; Slatter, 1992). However, small firm limitations with resources (Slatter, 1992; Rothwell, 1994), including difficulties with staff recruitment and retention (Rothwell and Zegveld, 1982; Caird, 1992) would support multi-tasking behaviours and weaken attempts to more formally organise the innovation process. The Japanese-inspired multi-functional team concept may have most to offer the medium-sized and large-sized company, since larger companies have greater problems with mechanistic organisation structures which: create problems for communication, co-ordination and staff integration; slow market responsiveness; and inhibit innovation and entrepreneurship (See Rothwell, 1989; 1992; 1994).

### **10.3 Inter-Company Alliances**

The implications of firm size for understanding innovation advantages and economic impacts (as described in Section 2.4) are obscured and potentially negated in inter-company alliances and team approaches. Although the present research did not focus specifically on the influence of inter-company alliances on organisational team approaches, the findings showed that inter-company alliances were associated with:

- more complex team processes
- more innovative project developments;
- greater formality in the operations of small firms;
- problems for teams in general (it was the second most frequently mentioned problem), although multi-functional teams experienced fewer problems than other team types;
- a stimulus for organisational learning together with organisational change;
- an explanation for mixed effectiveness ratings for team performance.

The challenges of inter-company alliances reflected the complexities of project management and control across organisational boundaries. Furthermore, several cases highlighted problems in managing inter-company projects which reflected the different cultures, agendas and priorities of companies in alliances of greater or lesser dependency and inter-dependency between companies.

The association between teams in innovation management and inter-company alliances lends support to Rothwell's 'Fifth Generation' or SIN model of innovation (Rothwell, 1994) which recognised the impact of major new technologies on increasing technological competition, speeding up product cycles leading to greater inter-company networking (Rothwell, 1992). It further supports claims that there is a paradigmatic shift taking place in the management of innovation due to the pressures of international competition (Hayes *et al.*, 1988; Susman, 1992; Wilemon and Millison, 1994; Jelinek and Litterer, 1994) and the increasingly complex nature of team approaches to innovation developments.



#### **10.4. Level Of Project Innovation**

The literature presented complex and sometimes contradictory evidence on the appropriateness of multi-functional teams to projects of varying innovation. There were suggestions in the literature that different forms of multi-functional teams may be appropriate to incrementally innovative projects as distinct to radical innovations, with different requirements for integration in each case.

The present research supported the appropriateness of multi-functional teams to major and minor innovative projects as well as routine projects, although the nature of the team differed for projects of varying innovation. Multi-functional team approaches to both minor and major innovations tended to require drafting in staff to different phases of the development process to work either interactively, in parallel or sequentially at times during the development process. This contrasted with multi-functional team approaches to routine projects where staff tended to be continuously interactive throughout the innovation process. Multi-functional team approaches to developing more innovative projects tended to be less continuously interactive than such approaches to developing routine projects; the former situation often included a dedicated R&D team effort as part of the team approach. For major innovations, the multi-functional team tended to have more staff representing several different scientific, engineering and technological disciplines than minor innovations or routine projects and were led by staff with technological expertise.

These findings support previous research which found that different multi-functional team approaches may be appropriate to incremental and radical innovations (Johne and Snelson, 1989; Barczak and Wilemon, 1991). Furthermore, there is support for the view that different types of staff expertise need to be integrated when projects vary in innovation (Katz and Tushman, 1979; Barczak and Wilemon, 1991).

The present research also supports Rothwell's assertion that technological innovation requires concomitant organisational innovation (Rothwell, 1992). However, views that incremental innovations may be developed within existing structures (Rothwell, 1992; Potter *et al.*, 1994) or organised by in-house departments, teams and committees (Johne and Snelson 1989) were not fully supported since the research findings found that both minor and major innovation developments in companies often required or led to other structural changes such as the use of teams, inter-company alliances and occasionally new business formations. This supports Rothwell's 'Fifth Generation' or Systems Integration



And Networking' model of innovation, where innovation is managed increasingly through inter-company networking, alliances and integrated teamworking (*ibid.*, 1992).

### **10.5. Nature Of Markets**

Maccoby claimed that different team competencies are required in different technological and market circumstances; standardised product developments directed at open markets require a greater ongoing input from marketing than customised client-funded projects which depend more crucially on direct relations with the customer for success (Maccoby, 1990). The findings of the present research showed that when projects were directed at client-funded markets, multi-disciplinary teams were more typically used. Marketing and sales were typically absent from the multi-disciplinary team, although involved at the initial pre-project development phase on client-funded projects. This appeared appropriate when the contract was secured. In some cases, multi-functional teams were appropriate to client-funded projects which required both a marketing and technical solution to a client problem. Multi-functional teams were more appropriate to innovative products and processes directed at open markets than either single-disciplinary or multi-disciplinary teams.

### **10.6. The Nature Of Organisational Teams**

Although recognising variations in organisation structure and its influence on organisational team approaches, the research findings presented a simple typology of team approaches which classifies teams as single-disciplinary, multi-disciplinary or multi-functional teams. However, the research found that organisational team approaches to the development of innovative products and processes tended to have blurred, previous team boundaries. The boundaries became less clear when more departments and companies were involved with the team approach and when projects were not merely routine. Integrated teams, both multi-functional and multi-disciplinary teams typically had blurred team boundaries as indicated by difficulties that team members experienced in estimating and agreeing on the size of the team and its membership. Team members in multi-disciplinary and multi-functional teams adopted for developing innovative products or processes, were one of several resource flows which were managed by project co-ordinators concerned with integrating staff expertise and other resources throughout the innovation process. The co-ordinator's role was therefore important for the effectiveness of such team approaches. However, the membership of the teams was typically fixed when



only one department or company was involved with the development of the innovative product or process or when teams worked on routine projects.

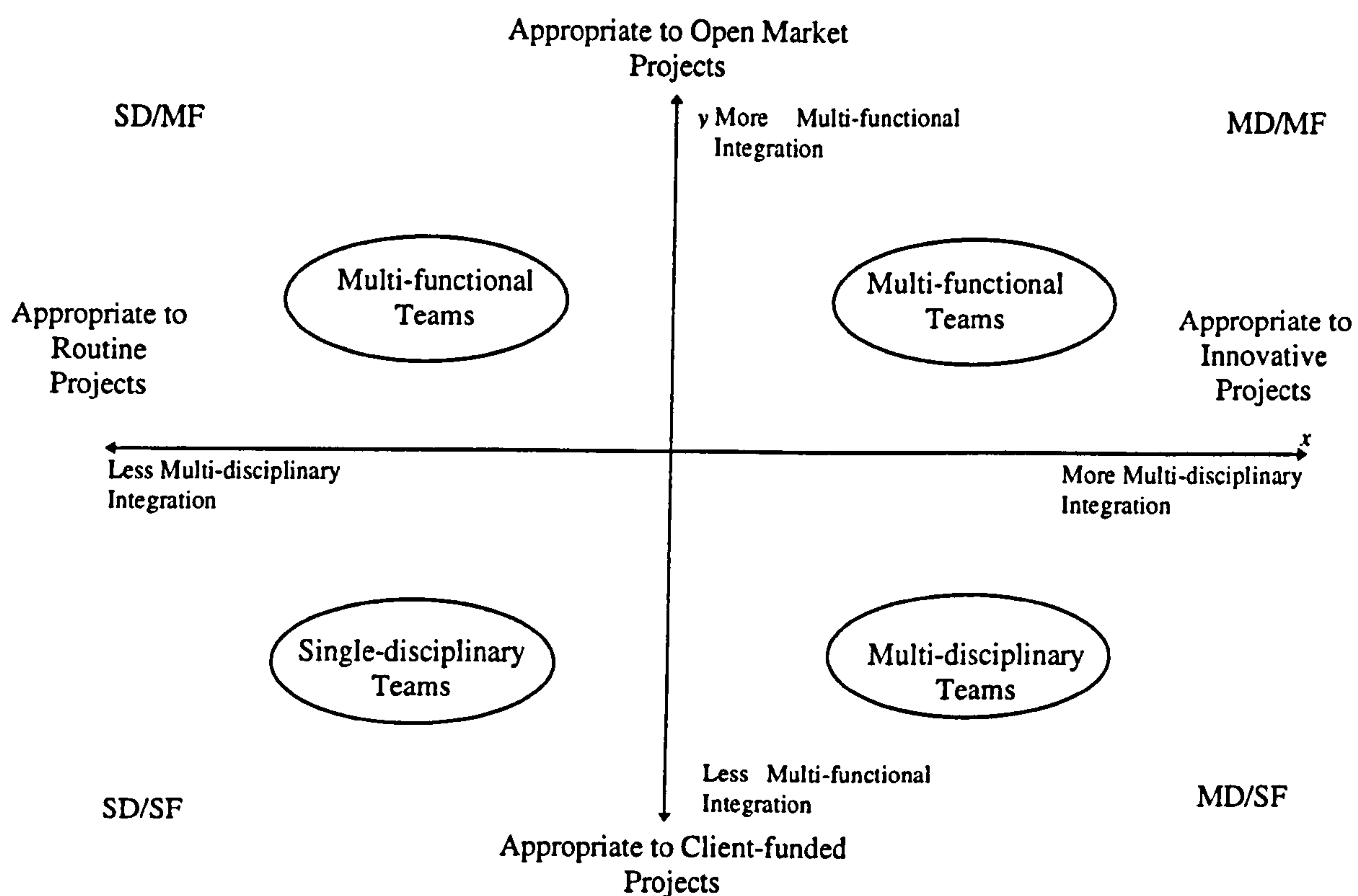
The idea that integrated team approaches have blurred, previous team boundaries contradicts the concept of the organisational team as one with fixed membership and fixed boundaries, which is typically presented in the management literature (See Belbin, 1981; Ancona and Caldwell, 1992; Katzenbach and Smith, 1993). This was therefore a surprising result which questions basic assumptions about the nature of organisational teams and implies difficulties for team classification, observation, management and team building.

#### **10.6.1. Multi-Functional, Multi-Disciplinary and Single-Disciplinary Teams**

The research supported the hypothesis that there are different types of organisational teams differentiated by the extent of integration of functional departments and staff with diverse expertise over the development process. Both single- and multi-disciplinary teams were technical teams. However, single-disciplinary teams were distinguished from multi-disciplinary teams on the basis of team expertise and multi-disciplinary teams held more disciplinary expertise within the team. Single-disciplinary teams tended to be intra-departmental unlike multi-disciplinary and multi-functional teams which were more typically inter-departmental and therefore more integrated. Multi-functional teams were characterised by a team membership which has responsibility for meeting all functions associated with innovation, unlike both single-disciplinary and multi-disciplinary teams.

Section 6.1 has described in detail the Team Matrix Of Organisational Team Approaches To Innovation in detail. Figure 10.1 presents the implications of such team approaches to projects directed at different markets and with different levels of innovation.

Figure 10.1 Team Matrix Of Organisational Team Approaches To Innovation And Appropriateness For Projects



**X axis** - disciplinary integration - scientific, engineering or technological disciplinary expertise- teams may integrate more disciplines with multi-disciplinary (MD) integration or less disciplines with single-disciplinary approaches (SD). This is associated with team appropriateness to projects with different levels of innovation.

**Y axis** - functional integration - business functional expertise such as sales, marketing, production, purchasing, finance, law etc.- teams may integrate more business functions with multi-functional integration (MF) or less functions with single-functional approaches (SF). This is associated with team appropriateness to projects directed at different markets.

Team approaches to developing innovative products and processes were classified on the basis of both members' disciplinary expertise and their project development function:

- the extent of multi-disciplinary integration varied and more innovative company project teams tended to integrate more disciplinary areas of expertise;



- there could be more or less multi-functional integration of functional representatives or departments and greater multi-functional integration within teams was more important for projects directed at open markets than for client-funded projects.

All single-disciplinary and multi-disciplinary teams were co-ordinated by technical staff with an absence of marketing and sales staff from the team. This seemed appropriate to multi-disciplinary team approaches, since they were either client-funded or internal technology development projects. However, several of the single-disciplinary teams which developed products for open markets excluded relevant business functional expertise, such as marketing from the team. When innovation developments were directed at open markets a multi-functional team was more appropriate than either a single-disciplinary or multi-disciplinary team approach.

Figure 10.1 represents multi-disciplinary integration as one dimension which describes team approaches to innovation developments and greater integration is appropriate to projects with higher levels of innovation. This supports Adler's view that greater levels of innovation may favour horizontal integration between involved departments (Adler, 1992). It also supports the finding that more effective innovative projects required communication with several experts representing different disciplines (Katz and Tushman, 1979).

The implications of the team classification presented in Figure 10.1 are that less innovative routine projects typically contain less disciplinary expertise. Katz and Tushman found that routine projects were more effective when members communicated with more representatives of different functions, such as suppliers, vendors, customers etc. (Katz and Tushman, 1979), which would suggest the value of high multi-functional integration, but not multi-disciplinary integration for routine project teams. However, the research findings imply that routine less innovative projects targeted at open markets require the integration of different functional representatives to those involved with client-funded projects: the former favouring multi-functional team approaches and greater multi-functional integration; whereas the latter favours single- or multi-disciplinary team approaches (multi-disciplinary teams for more innovative projects) and lower multi-functional integration, albeit with the possible involvement of clients. This relates to the second important dimension for classifying team approaches to the development of innovative projects (Figure 10.1) which is multi-functional integration with its relative importance for and appropriateness to different markets. Furthermore, the dimension of multi-functional integration is related to Adler's concept of vertical integration between design,



manufacturing and marketing departments which is important for projects with greater 'design analysability' concerns (Adler, 1992).

Figure 10.1 needs to be supplemented by findings which emphasise the complex, diverse nature of multi-functional, multi-disciplinary and single-disciplinary team approaches to the development of innovative products and processes. The adoption of team approaches by organisations to developing innovative projects is complex, often involving several departments, teams or companies in the process, particularly for more innovative projects and for projects directed at open markets. On Figure 10.1 this would be represented by the high MD and MF points and includes both multi-functional and multi-disciplinary teams. However, the research shows that the distinction between single-disciplinary, multi-disciplinary and multi-functional team approaches is simplistic since there are other factors which complicate classification, such as inter-company alliances, firm size differentials, level of project innovation and the nature of markets which have been discussed above. Furthermore, team approaches vary in terms of the source of expertise and the nature and timing of staff integration during the development process.

Case studies of team approaches to innovation reveal a complexity and variability which emphasise differences within multi-functional team approaches particularly.

1. The co-ordinator's expertise could be technical, marketing or multi-functional. Major innovative products and processes tended to be co-ordinated by managers with a technologically-based multi-functional expertise.
2. The main co-ordination function could change at different project phases. The co-ordination function tended not to change hands in smaller companies, whereas in larger companies it typically changed hands between marketing, R&D and production staff at different phases in the development process.
3. The source of multi-functional expertise could either reflect staff specialist expertise as in most medium-sized and large-sized companies, or the multi-tasking activities of staff operating both within and outside their own area of specialist expertise, which applied to most small companies.
4. The multi-functional expertise could be supplied in-house or by several teams and companies. In the majority of cases there were several companies involved with the team approach.



5. The nature and number of disciplines and project functions involved with the project was different for every project under investigation, although more innovative projects tended to have more disciplinary expertise integrated with the team.
6. The nature and timing of staff integration varied in every project, although less innovative project teams were more likely to be continuously integrated, unlike more innovative project teams which had members drafted in at different phases to work in parallel, interactively and sequentially at different development phases. Furthermore, team approaches to developing more innovative products and processes usually integrated a separate dedicated R&D effort as part of the team approach.

These findings support views that inter-functional integration is not continuously required throughout the innovation process (Takeuchi and Nonaka, 1986; Hull and Azumi, 1989). Takeuchi and Nonaka recommended some integration or overlapping of project development phases, although teams may not require the continuous integration of members throughout the development process and in the 'sashimi system' team members representing different functions integrate at the border of adjacent phases (Takeuchi and Nonaka, 1986). In contrast with this idea of inter-functional integration taking place at the beginning and end of development phases, Hull and Azumi argued that greater integration is less necessary upstream when commercial applications are unclear (*ibid.*, 1989) and instead creativity is more important at this stage (Hull, 1990). Hull and Azumi argued that the value of the multi-functional team may be highest during the middle phases of the innovation process when divergent perspectives need to be assimilated during the transfer of upstream ideas down-stream (Hull and Azumi, 1989). The importance of inter-functional integration during the middle phases of the innovation process is also supported by Schewe's emphasis on the 'transfer efficiency' of the project from development to marketing as an important innovation success factor (Schewe, 1994).

However, although this research supports the idea that full inter-functional integration does not typically characterise the whole innovation development process, this study found that inter-functional integration in multi-functional teams was greatest in the early and final phases of the development process. Although the diversity in company approaches and their effectiveness suggest that this finding is not necessarily indicative of best practice and should be treated cautiously, it supports Hayes emphasis on the pre-project planning phase where managerial influence on the direction of the project is greatest (Hayes *et al.*, 1988).

### 10.6.2. Non-Team Approaches

Approaches to project management are determined by numerous factors including: the size of the project; the budget; the availability of in-house skills; the technologies employed; the level of project innovation; the requirement for setting up new manufacturing routes; traditional organisational approaches; the involvement of commercial and public organisations including universities with the project; the goals of the project; the potential for commercialisation; and the markets. The innovation process may be co-ordinated by a variety of mechanisms in addition to teams, such as formal rules, plans, design reviews, project managers as liaison officers and committees (Alder, 1992; Hayes *et al.*, 1988; John, 1985). Co-ordination may be facilitated by the loose coupling of functions through: shared values; leadership; the implementation of information technology; super-ordinate goals; the physical proximity of staff; the accessibility of staff; and appropriate reward structures (Hitt *et al.*, 1993; Pinto *et al.*, 1993). This study found that companies which did not favour team approaches had the following reasons:

- the project was too small to justify a team approach;
- the team represented the potential for time wastage;
- there were resource limitations, of staff, finance, time and skills;
- the company gave a low priority to project completion due to business pressures;
- the company was antagonistic to the egalitarian ideal represented by the team concept;
- teams could be inappropriately dominated by individual members;
- there was a danger of teams becoming over-formal and bureaucratic.

This supports Adler's view that teams are not the only and most appropriate co-ordination mechanism and less interactive mechanisms may be preferable since more interactive methods can be time consuming and too expensive (Adler, 1992). Although teams may not represent the best approach to the development of innovative products and processes, the majority of team members regarded team approaches as essential for big projects with time pressures.



### **10.6.3. Evaluation of Team Approaches**

The literature suggests that teamwork, particularly teams involving the integration of staff with different disciplinary expertise and representing different project functions, offers mixed benefits and disadvantages for project development outcomes. The findings support the theoretical proposition that team effectiveness is difficult to achieve due to the influence of complex group processes (See Handy, 1993). This research programme found that multi-functional teams were not without their problems, especially with task management. Indeed differences in the distribution of problems associated with each type of team approach were not significant. However, multi-functional teams experienced the least number of team problems with managing external relationships which was the source of greatest problems for single-disciplinary and multi-disciplinary teams.

Ratings of greater team effectiveness were significantly higher amongst teams which experienced fewer problems. However, irrespective of effectiveness ratings, all teams experienced problems. The experience of problems did not automatically lead to low ratings of satisfaction or effectiveness, particularly if the innovative development project represented an opportunity for team learning. For example, although the multi-functional teams with mixed ratings of effectiveness experienced significantly more problems than effective teams, they also learned more and mentioned more positive aspects of team operations than effectively rated teams. Task management may have caused the greatest problems for multi-functional teams, but it was also an area where learning occurred in several teams that were addressing the challenges of more innovative project developments or organisational changes to the management of project development work.

In general, multi-functional teams received more mixed ratings of effectiveness than single- or multi-disciplinary team approaches, even though they experienced fewer problems with external relationships than both other team types and teams rated as effective. This finding suggests that team effectiveness (as indicated by team member perceptions) was not strongly influenced by the experience of external relationships, either in-house and inter-company relationships, even though this may be of equal or greater importance for project outcomes. This supports earlier research by Ancona which found that effectiveness in internal group processes predicted team member satisfaction and team ratings of performance and was inversely related to effective external relations, while effectiveness in external relations were associated with poor cohesion and lower satisfaction even though it predicted sales revenue (Ancona, 1992).



It appeared that mixed ratings of multi-functional team effectiveness were due to the greater multi-functionality of these teams. This is unsurprising since there is support for the negative impacts of functional diversity in team membership, which include: communication disharmonies (Souder, 1988); emotional-based conflict (Pelled and Adler, 1994); difficulties establishing cohesiveness; openness to political and goal conflicts; less ease with teamwork; and worse performance (Ancona and Caldwell, 1992). An alternative explanation for the greater number of mixed effectiveness ratings among multi-functional teams is that multi-functional teams with such ratings had more problems with task management as well as team interaction issues. This was unsurprising since multi-functional teams were more typically associated with *more* innovative projects which were directed at open markets. Such projects were associated with more potential problems than customised, client-funded projects, particularly relating to the influence of markets and the project's technological complexity which bring additional concerns and responsibilities to the attention of the team. More innovative projects directed at open markets may require more inter-company liaison and learning or innovation within teams. These explanations may all apply and may not be separable or exclusive. In general, it would appear that multi-functionality of membership, the broader remit of the multi-functional team which includes marketing and technical goals, as well as the problems associated with developing more technologically innovative projects for open markets all have a negative influence on team effectiveness ratings.

Chapter 8's findings support the significance of multi-functionality in team membership as a negative influence on team member ratings of team effectiveness. It would appear that the more multi-functional the team member composition the more likely team members will give mixed or low ratings of effectiveness. However, there is a need to explain why teams given low or mixed effectiveness ratings may produce good project success outcomes and why teams rated as effective were not consistently associated with good commercial outcomes. This contradicts the Katzenbach and Smith 'Team Performance Model' which implies a direct positive relationship between team effectiveness and performance outcomes (Katzenbach and Smith, 1993).

The association between team member ratings of effectiveness and subsequent project success outcomes may be elucidated by team perceptions of goals and responsibilities. The findings suggest that teams which pursue technical goals alone may rate themselves as effective, whatever the commercial outcomes, since commercial outcomes are not regarded



as their responsibility. Such teams may avoid the interaction and integration problems associated with multi-functional teamworking which negatively influence team ratings of effectiveness. Furthermore, a more homogeneous team may be less likely to be innovative since many innovations originate in the integration of different disciplines and business functions which brings together an awareness of both technological and market opportunities (See Von Hippel, 1988; Drucker, 1991; Roy, 1992; Caird, 1994a). This may mean fewer problems for such teams associated with developing and marketing innovative products for new markets. Indeed the research supports a statistically significant relationship between team effectiveness ratings and the experience of fewer problems. The significance of homogeneity of team member expertise, fewer problems and the team's perception that goals and responsibilities are limited to a technical remit may explain why team performance may be rated as effective, even when success outcomes are poor. In other words, this apparent anomaly in the impact of team effectiveness on commercial success may be explained by factors internal to the team.

Teams with both technical and commercial goals are less likely to be rated as effective than teams with a technical remit, even if good commercial outcomes are achieved by the former and not by the latter. Problems associated with multi-functional teamworking, the wider team remit which includes both commercial and technical goals, the greater market pressures and sometimes technological pressures on multi-functional teams account for poorer effectiveness ratings, even when projects are subsequently commercially successful. In this case, the relation between team effectiveness and subsequent commercial outcomes may be explained by factors both internal and external to the team.

Existing research suggests that success outcomes may depend on the effectiveness of team boundary spanning behaviours (See Ancona and Caldwell, 1987) and the effectiveness of external relations, despite associations with poor cohesion and lower satisfaction (Ancona, 1992). Although multi-functional teams were not regarded as effective as other teams, they experienced fewer problems with their external relationships than effectively rated teams and other types of teams. This suggests that the effort to bring more project functions into the multi-functional team approach may create more internal problems and account for lower ratings of effectiveness, although it may prove better for overall project outcomes. It is interesting that the commercial success of projects launched on open markets was achievable by multi-functional teams even though team members were dissatisfied with the effectiveness of their team's operations. The broader remit of multi-functional teams

means that a wider set of issues are brought under the control and responsibility of the teams which may account for the dominance of multi-functional teams amongst projects with good commercial outcomes in open markets.

### ***10.7. Recommendations For Team Management***

Thus it was clear that multi-functional teams were not a panacea for problems experienced with the development of innovative products and processes. Several multi-functional teams experienced problems putatively alleviated by multi-functional teams, such as inter-functional rivalries and blame, poor project development timing and co-ordination, and communication problems (See Section 2.1). There were several cases where R&D was blamed by marketing for delays on marketing-led projects or when production expertise was not consulted by R&D staff. On the other hand, at least 50% of multi-functional teams reported benefits with the following: improving multi-functional integration; producing a better-quality product; targeting the market appropriately; and making good time-to-market. Thus, it was also clear that several multi-functional teams experienced many benefits from the adoption of this team approach.

Insights into team processes were drawn together in Chapter 8. The following summarises some important recommendations, on how to improve the management of both inter-functional relations and inter-company relations in team approaches.



### **Recommendations for Improving Team Relations Between Staff Representing Different Areas of Functional Expertise**

1. When the development of innovative products and processes are led by marketing, it is important that marketing acquires sufficient understanding of the R&D function for project planning and development time estimations.
2. Inter-departmental projects should be planned using evaluations of previous projects rather than depending entirely on previous project plans or wish-lists. Openness on project plans helps staff involved at early phases to be aware of their responsibilities towards staff involved at the later stages. This can help staff to be more goal-oriented and achieve better development time.
3. The inventive phase of the innovation development process can be difficult to manage and inexperience in new areas of innovation tends to lead to underestimations of project resourcing requirements, including time, staff and finance, in addition to other unconfirmed assumptions about how staff, teams and companies will work together.
4. Inter-functional communication problems can be alleviated by keeping teams small, promoting long-term staff tenure and encouraging staff to think beyond the boundaries of their functional expertise.
5. Informal communication, close proximity of staff and a frequent in-house staff presence can facilitate inter-functional integration.
6. The management of the team members' transition to new project teams needs to be managed in a non-destructive way which is sensitive to team member bonding and which recognises the potential for staff to work together on future projects.

### **Recommendations for Improving Team Relations Involving More Than One Company**

1. Inter-company relations may be enhanced by considering differences in the culture, values, priorities, attitudes and operations of partners early on and this information may come from discussions as well as company information and organisational charts.
2. Inter-company project management can be difficult because of a lowered power to command and a reduced awareness of what is going on in other companies. This emphasises the importance of the project manager's ability to assess people and companies in terms of their capability and reliability.
3. Attention needs to be paid to the nature of inter-company dependencies and inter-dependencies, since some arrangements carry more risk than others; dependent relationships are particularly risky if one company depends on the partner to perform essential business activities, such as marketing.
4. Inter-company teams provide opportunities for organisations to learn about how other companies operate. This could support organisational change and development programmes. However, it can lead to an awareness of differences between companies which can create unease or embarrassment, if the inadequacies of one company's organisation and management are highlighted.
5. Companies which aim to exploit partners for short-term gains have short-term alliances. Recognition of the potential for long-term and future project associations leads to the valuing of co-operation in inter-company relations.



## **10.8. Impact Of Team Approaches On Innovation Success**

Irrespective of the team approach adopted, 96% of the teams attained satisfactory technical outcomes. Although it is alleged that multi-functional teams deliver better-quality products (See Hayes *et al.* 1988), the present research suggests that technical success was achieved by all team approaches. Commercial success outcomes were more diverse, with only 33% of the teams attaining good commercial outcomes. Multi-functional team approaches were not more frequently associated with greater commercial success than other team approaches in general, although they were adopted in all cases of successful projects in open markets. However, this was a small sample and there was a large number of client-funded projects for which multi-functional teams were not as appropriate as multi-disciplinary or single-disciplinary team approaches.

The majority of teams (96%) regarded the team approach as necessary to the development of innovative products and processes and responsible for positive project outcomes. Although there was no obvious relationship between team effectiveness ratings and commercial success which in general depends on several market, organisational, project and human resource factors (See Table 2.9), in-depth analysis showed that all of the successful client-funded projects were developed by teams rated as effective. When projects were fully client-funded, market uncertainties were largely removed from the team and the key influences on project commercial success included the effectiveness of project management, the client relationship and the integrated team approach.

When innovative product and process developments were directed at open markets, the relationship between team effectiveness and project success outcomes was more complicated (See Sect.10.6). Success depended partially on the companies access to complementary assets such as marketing and manufacturing capabilities (See Teece, 1986) which was particularly significant for small firm lack of commercial success and partially on characteristics of the environment industry. This together with internal team issues accounted for the impact of the team on project success in open markets.

Moderately or highly commercially successful projects tended to address existing markets which were either supported by enforced legislation or customer interest. The least successful projects were dependent on the enforcement of environmental legislation in the US, EU or UK as the stimulus to market creation and achieved little commercial success when regulations were not enforced. The study shows that many proactive companies,



which innovated with the expectation that EU Directives would be enforced in the UK, were disappointed leading to project failures and financial losses. This may explain earlier research, carried out by the author and other researchers, on innovators competing for the Environment Award for Engineers which found that 18% of the sample cited legislation as a *problem* for their projects (Caird *et al.*, 1994).

Environmental products typically confer costs on the customer and with the exception of one company customer none were willing to buy products which offered more than was required by existing enforced legislation at extra cost. This included the recently privatised water companies and the new companies which have formed from privatised British Coal which were no more willing to take on unnecessary extra costs than other companies. This was the case even when a water company incurred significant costs as a development partner for a product designed to meet the sewage treatment legislative requirements of the EU Urban Waster Water Directive which is unenforced in the UK at present. These privatised companies had therefore a restraining influence on the growth of the environment and pollution control industry. However, it was clear that the water companies were a complex influence on the industry from the evidence of their numerous company acquisitions and support for the commercial operations of technologically innovative companies either as customers or through joint-ventures or acquisitions.

It is arguable that team effectiveness has a greater influence on the commercial outcomes of client-funded projects than on projects targeted at wider markets, since clearly more conditions for innovation success need to be met for the latter, particularly market-related factors. Greater challenges are posed by the development of innovative products and processes directed at wider, less guaranteed markets requiring more multi-functional team approaches. In this situation, team effectiveness is more difficult to achieve and although important, it may be less influential on ultimate commercial success which depends both on company access to complementary assets and to government enforcement of legislation in emerging but dependant markets. Although the literature recognises the importance of team approaches for project success outcomes, greater significance has been historically given to market and technology related factors than organisation, project or human resource related factors. However, this research shows that multi-functional team approaches, which pertain to organisation, project and human resource influences on innovation success are part of the profile of successful innovative products and processes.



Since the White Paper on 'Realising Our Potential: A Strategy for Science, Engineering and Technology' attests to the importance of supporting wealth creating innovative products and processes (OST, 1993) and the OECD have outlined the growing market opportunities emerging within the environment industry (OECD, 1992), one might expect that priority would be given to supporting environmental technological products and processes. Delays in the enforcement of environmental protection legislation in the UK, together with moves towards deregulation have created an uncertainty about market demands and trends. This creates difficulties for companies trying to innovate in emerging environmental markets where products often confer no commercial benefits on customers, including the reliance on exports as their main survival option when a strong home market is important for company solvency. The alleged UK failure to support these markets, either through targeted government funding or legislation enforcement seems short-sighted, in view of growing opportunities and the evidence that the UK is lagging behind other OECD countries in these markets (*ibid.*, 1992).

## **10.9. Conclusions**

The research builds on existing research on teamwork in organisations involved with the development of innovative environmental products and processes. The question of whether the team and in particular the multi-functional team offers the best solution to the integration problems posed by the innovation process cannot be fully answered because of both the diversity in company team approaches and the complexity of teams in terms of inter-disciplinary and inter-functional integration and inter-company collaborations. There is considerable diversity in the adoption of team approaches in companies which are influenced by firm size, inter-company alliances, organisational structure, level of project innovation and types of markets in which the company operates. The findings show that the recommended new paradigm multi-functional team, identified by Hayes *et al* is too simple a view of the innovative team approaches which may be adopted to co-ordinate innovation developments (Hayes *et al.*, 1988) and in particular, the Hayes concept of a multi-functional team does not acknowledge the possible involvement of several sub-teams and companies with the team approach.

While recognising the complexity and diversity of organisational team approaches, the study developed and applied a classification of team approaches which contrasts single-disciplinary teams with two types of integrated teams, the multi-functional and multi-disciplinary teams. Multi-functional teams, while not an automatic panacea for problems



associated with the development of innovative products and processes, were associated with benefits and success outcomes in many participating companies. Multi-functional teams were more appropriate to projects directed at open markets than client-funded projects and were typical amongst the most commercially successful of these projects. However, the multi-functional team requires careful management in order to address the tensions of inter-functional integration and the organisational complexities of inter-company collaborations. While the influences on team effectiveness ratings were complex particularly for multi-functional team projects directed at open markets, the relationship between team effectiveness ratings and commercial outcomes was more clear when projects were developed for clients. The findings on successful client-funded projects support the importance of team effectiveness for innovation success clearly since the influence of external market-related factors are largely controlled.

This relatively small sample of case studies has helped to generate in-depth insights into complex organisational processes. Team research is important and the majority of participating companies regarded the team as an essential approach to innovation management in the 1990's. Both the qualitative and quantitative results are suggestive of trends which are worth following up in further research. Further research could build on the present research's contribution to improving an understanding of team approaches in innovation. Further research to investigate the following would be interesting, favouring a case study in-depth approach for items 1-3 below and a large sample survey for items 2, 4 and 5 below:

1. the best practice in the implementation of multi-functional teams, since the present research shows that there is considerable diversity between teams, in terms of both the source of expertise and the extent of integration of project associates at different phases of the innovation process;
2. the advantages of different types of team and non-team approaches, since teams are not always the best approach to developing innovative products and processes, as demonstrated by cases of non-team approaches;
3. the nature and impact of dependency in inter-company team approaches, with particular attention to the position of the small firm;
4. the relationships between team approach and satisfaction; team approach and effectiveness; team approach and commercial success; team effectiveness and

commercial success; and team satisfaction and commercial success which would need to be tested on a bigger sample;

5. the importance of the team in developing innovative products and processes for different markets where the potential for achieving sales varies in certainty. A focus on client-funded projects could prove the validity of findings on the importance of team effectiveness. A focus on projects targeted at open markets could prove the validity of findings on the importance of multi-functional teams for commercial success and elaborate on the explanation for how teams may be successful without being rated as effective.

This research has drawn on several disciplines, including organisational theory, innovation theory and psychology to conduct an in-depth case study analysis of team approaches to the development of innovative products and processes. This is important because psychological research on groups has been largely limited to the laboratory and management research has focused more on formal and informal organisational structures (Ancona and Caldwell, 1992), largely ignoring teams which are quasi-formal structures (See Jelinek and Schoonhoven, 1990). The findings include in-depth descriptions of organisational team approaches and the analysis of this rich case study material contributes to our understanding of the team as a quasi-formal organisational structure, an area where the theoretical literature is limited in its understanding.

In conclusion, this study assists the search for new models of innovation management which have been deemed necessary to address the competitive challenges of higher productivity, faster product cycles, higher quality and lower costs in an increasingly internationalised industry, transformed by technological change. The results lead to the following conclusions:

1. Multi-tasking to meet all innovation functions reflected small firm limitations, associated with project resourcing, staff recruitment and retention, and small firms would benefit from more formal structures. Differences between medium- and large-sized firms were minimal since teams held more specialist expertise. This suggests that the association of small- with medium-sized enterprises (SME) (Rothwell, 1994) is unhelpful since medium-sized firms behave more like large firms.



2. The implications of firm size for understanding innovation advantages and economic impacts are obscured and potentially negated in inter-company alliances and inter-company team approaches.
3. There were few differences in the management of minor and major company innovations since competitive pressures lead to organisational innovation in each case, including integrated team approaches, inter-company alliances and company formations. This supports Rothwell's assertion that technological innovation requires concomitant organisational innovation and the 'Fifth Generation' model of innovation in the 1990's (Rothwell, 1992). However, it contradicts literature support for the different management requirements of minor and major company innovations and suggests that the 'Fifth Generation' model of innovation applies equally to minor and major company innovation developments.
4. Multi-functional teams were important for achieving success in open markets because of their control over appropriate expertise, even though they did not guarantee commercial success or other benefits. Surprisingly, despite commercial success multi-functional teams were typically rated as unsatisfactory and ineffective by members which may have implications for staff morale and retention.
5. Inter-company teams represented significant opportunities for team learning and organisational development because company-based assumptions about organisational behaviour, expectations about inter-company operations and fears about inter-disciplinary teamworking were challenged.
6. Integrated teams were not sufficient for achieving team effectiveness and other success outcomes, although most companies regarded their team as necessary for success. Complex team and innovation development processes emphasised the importance of the project co-ordinator's role in managing the unclear team and organisational boundaries associated with innovative developments.
7. Although teams were not always advantageous in innovation, the findings support their importance for innovation success. However, team effectiveness had a more complex influence on success in open markets than on client-funded projects because of the nature of the teams and the influence of market and technological uncertainties.

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# Appendix 1 Innovators Competing For The 'Environment Award For Engineers'

## Letter And Questionnaire

Ms Sally Caird,  
Centre for Technology Strategy,  
Faculty Of Technology, Systems,  
The Open University,  
Milton Keynes,  
MK7 6AA.

January 1993

Dear Entrant,

I am writing to invite you to participate in a study of companies involved in environmental technological projects. This study emerged from our awareness, at the Open University, of the growing market for environmental technological products and a concern with Britain's competitiveness in EU and international markets. We hope that the study will provide information, which will ultimately help companies, such as yours, to approach the product innovation process more effectively for improved commercial results. The Engineering Council and British Gas have granted us permission to approach you and to request your participation in this study. However, I would like to assure you that the study is entirely independent of the Environment Award for Engineers and that your response will have no bearing on your Competition entry.

As an initial step, I should be grateful if you would respond to the following questions and return your response in the enclosed stamped addressed envelope. We would like to assure you that we will treat your responses with strict confidentiality and will refrain from publishing any information which you disclose, which could be used to identify your company or project. We may be in contact again to request more detailed information later this year. If you would like to receive the final results of this study, please mention that in your response. We are very grateful for your co-operation with our project.

I look forward to receiving your response.

Yours sincerely,

Sally Caird (Ms)  
Research Fellow



## PROJECT TITLE: ENVIRONMENTALPRODUCT INNOVATION

We may need to contact you again for more detailed information, so please write your name, address and telephone number below.

Name: \_\_\_\_\_

Address: \_\_\_\_\_

Telephone Number: \_\_\_\_\_

1. Could you briefly describe your environment project? Please include its main applications:- \_\_\_\_\_

2. How do you plan to take your environment project forward?

3. Have you commercialised your project? Yes ☐ No ☐  
*please tick one box, if your response is yes go on to question 6*

4. Do you intend to commercialise your environment project? Yes ☐ No ☐  
*please tick one box, if your response is no go on to question 6*

5. How close to commercialising your environment project are you, in terms of months?\_

6. Are you working on your environment project (*please tick one box*)

As part of your work as an employee for an organisation (*go on to question 8*) ☐

In your own time, outside your regular employment (*go on to question 10*) ☐

Within your own business ☐

7. In what year was your company registered?\_\_\_\_\_

8. What is your position/job title in your company?\_\_\_\_\_

9. How many people work within this organisation?

The whole organisation

☐

Your division/subsidiary

☐

10. How would you describe your role and personal contribution to the environmental project?

---

11. How many people are working on the project? \_\_\_\_\_  
if there only one person is involved, go on to question 13

12. Briefly outline the roles of the people involved in the project

13. Which, if any, of the following factors have proved, or are likely to become a problem, to the progress of your project?

13(A) Please tick boxes beside relevant factors.

13(B) Add any additional factors, which you regard as problems, to the end of the list.

13(C) Please rank order the top five factors which you have identified, in terms of their significance for the progress of your project. Give the rank of 1 to the most significant problem, 2 to the second most significant and so on.

Factors	tick box	rank order
Establishing technical viability	<input type="radio"/>	<input type="radio"/>
Securing a patent	<input type="radio"/>	<input type="radio"/>
Securing financial backing	<input type="radio"/>	<input type="radio"/>
Managing cash flow	<input type="radio"/>	<input type="radio"/>
Personal financial risk	<input type="radio"/>	<input type="radio"/>
Obtaining basic resources and equipment	<input type="radio"/>	<input type="radio"/>
Managing or working effectively with staff	<input type="radio"/>	<input type="radio"/>
Recruiting and retaining staff working on the project	<input type="radio"/>	<input type="radio"/>
Setting up a collaborative partnership with companies	<input type="radio"/>	<input type="radio"/>
Controlling the development of the project	<input type="radio"/>	<input type="radio"/>
Organisation's support for the project	<input type="radio"/>	<input type="radio"/>
Personal problems, e.g. lack of motivation or depression etc.	<input type="radio"/>	<input type="radio"/>
Conflicting demands between existing business and the new project	<input type="radio"/>	<input type="radio"/>
Poor timing in project development	<input type="radio"/>	<input type="radio"/>
Establishing market demand	<input type="radio"/>	<input type="radio"/>
Consumer resistance to new products	<input type="radio"/>	<input type="radio"/>



Factors	tick box	rank order
Competing in uncertain markets	<input type="radio"/>	<input type="radio"/>
Economic climate	<input type="radio"/>	<input type="radio"/>
New legislation	<input type="radio"/>	<input type="radio"/>
<hr/>	<input type="radio"/>	<input type="radio"/>
<hr/>	<input type="radio"/>	<input type="radio"/>
<hr/>	<input type="radio"/>	<input type="radio"/>

Other Comments 

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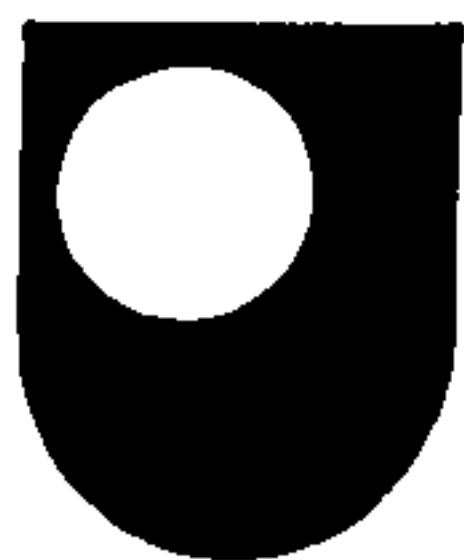
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Thank you for your co-operation in completing this questionnaire

Appendix 2 Interview Questionnaire



The Open University

Centre for Technology  
Strategy

Innovation - Environment -  
Development

ORGANISATION FOR  
ENVIRONMENTAL PRODUCT  
INNOVATION

COMMERCIAL - IN CONFIDENCE

Questionnaire  
Number:

Name of Company / Division .....

Address .....

Telephone Number .....

Name Of Interviewee .....

Job title .....

Date of Interview .....

Comments on Interview .....

.....

.....



**SECTION 2: BACKGROUND TO THE COMPANY/DIVISION**

*Could I begin by asking you to give me a brief history of the company, such as:*

**2.1      When was the company founded?**

.....

.....

**2.2      What is the legal status of this company?**

**Status of Company:**

UK-owned independent company

Part of UK-owned group

Part of overseas owned group

Other (please specify)

**2.3      What is the main business of the company?**

2.3.1. Since your company is involved in developing environmental products, I am interested in asking whether you have a company policy of relevance to environmental issues?

Yes

No

**2.4      How would you describe the way the organisation is structured?**

**Organisation Structure**

Discipline/department

Project/Product line structure

Matrix

Entrepreneurial structure

Dual Venture

Organic structure

Other

**2.5      How many people work within this organisation?**

The whole organisation

Your Division/Subsidiary



2.5.1. How many of them work in

research, design and development

sales and marketing

finance

production

other

**2.6** Since founding the Company what **SIGNIFICANT** events have shaped the company to become what it is today?

**2.7** Which are your main customers and market sectors? *(NB: public sectors, water utilities, industrial and domestic consumer markets. NB: directness of links to markets and collaborative ventures and whether international, national, regional, local)*

**2.8** Could you tell me about the main challenges and opportunities presented by the industry in which you are working?

*Please note whether a challenge (c) or opportunity (o)*

**SECTION 3: COMPANY PROJECTS**

**3.1** Could you briefly describe the new product development project/s, which you are working on within your company/division? *(NB: the number of projects and their main application).*

*From now on I would like to focus on one project, which has been recently commercialised or which will be commercialised within the next 6 months.*

**3.2** Would you describe this as an innovative project?

Yes

☐

No

☐

**3.2.1.** If yes, How innovative is it ?

VERY INNOVATIVE	QUITE INNOVATIVE	AVERAGE	NOT VERY INNOVATIVE	NOT AT ALL INNOVATIVE

**3.2.2.** If yes, How innovative is it perceived to be on the market?

VERY INNOVATIVE	QUITE INNOVATIVE	AVERAGE	NOT VERY INNOVATIVE	NOT AT ALL INNOVATIVE



3.2.3. Could you describe your understanding of what an innovative project is?

*(By innovative project I refer to the development of new products or processes to solve problems for commercial purposes or a significant improvement of existing products or processes.)*

3.2.4. If yes, what is the innovative feature of this project?

**Level of Innovation**

radical breakthrough

- undertakes an entirely new function

- would require a new textbook

major product innovation

- a major technical shift

- no equivalent on the market

- would require changes to several chapters in a text book

design variants and new models

- redesigns

- imitations

- would require minor alterations to the standard text

old/traditional

- either a very slight or zero change to a text required

Technology/ Application	application of existing technology	combination of existing technology	novel technology
new product			
established product			
new market			

*(NB: Probe for classification of product on scales of innovation and technology/application)*

3.3
Have you patented ideas arising from this project ?

Yes

No

3.3.1 If yes, which ideas?

3.3.2. If yes, have they been patented abroad?

Yes

No

3.3.3. If no, probe to find out why the product ideas have not been patented ?

3.4

Would you be willing to tell me what your budget for R&D expenditure on this project is?

£



3.5 In your view, was the budget for R&D realistic? Yes ☐

No ☐

3.5.1. Were you able to work within the budget for the project? Yes ☐

No ☐

3.6 Has this project been already commercialised (or completed for the client)?

If so, when was the project released onto the market/to the client?

If not, when will it be released onto the market/to the client?

Date

#### **SECTION 4: APPROACH TO PRODUCT AND PROCESS DEVELOPMENT PROJECTS**

4.1 How would you describe the way the development of this project is organised in your company? *(NB: team vs. non-team, type of team approach and changes during innovation development process)*

4.2 Where have the initial project ideas and the ideas for developing the project tended to come from? *(NB: the people associated with the development of these innovative ideas and their role and contribution to the project)*

4.2.1. Is there a key innovator? Yes ☐

No ☐

4.3      How many people have been involved in the project?

4.4      How would you describe your own role in the project?

*If only one person involved in the project development, go on to 4.9*

4.5      How would you describe the role and contribution of all those involved in the project? What sort of skills and expertise do they have?

*If it appears that there is a multi-disciplinary expertise in the group, confirm this.*

4.5.1. Is there a multi-disciplinary team approach to the project?    Yes   

No   

4.6      Were there any changes in the staff involved in working on the project?    Yes   

No   

4.6.1. If yes, what were the reasons for these changes?

4.6.2 Did this account for changes in the approach taken to project development?

4.7      *You have described/would you describe your approach to product development project's as a 'team approach'?*    Yes   

No



4.7.1. What is your understanding of a ‘team approach’?

*(NB: tick any boxes appropriate to this description)*

Size - (two or more members)

☐

Membership, Roles, Goals, leadership (members contribute their competencies within inter-dependent roles towards shared goals, for multi-disciplinary teams this competence is multi-disciplinary)

☐

Team Identity (distinctive team identity)

☐

Formal Communication Network (norms for internal and external communications)

☐

Norms for Operations (a formal structure facilitating organisation for project goal achievement)

☐

Purpose (life of team is limited to project or project’s achievement)

☐

Shared Responsibility (all members share responsibility and are accountable for project success outcomes)

☐

Appraisal (the team’s effectiveness may be evaluated on productivity, performance or success measures)

☐

4.8 Is this approach to product development projects a typical Yes ☐  
approach to product development in your company?

No ☐

*(NB: Probe and check attitudes to different approaches to product development)*

4.9 Could you briefly describe how the project development project has been supported by the organisation?

## **SECTION 5 PROJECT MANAGEMENT**

5.1 How would you describe the way this project has been managed?

*(NB: How was the project managed?)*

*How was the project managed over different phases of the project?*

*Who was in charge?*

*How were work responsibilities allocated?*

*How often did people meet?*

*What were the main reasons for meeting?*

*How was the progress of the project monitored over each phase of development?)*



**5.2. Which, if any, of the following factors have proved to be a problem affecting the progress of your project?**

5.2.1. Please tick boxes beside relevant factors.

5.2.2. Add any additional factors, which you regard as problems, to the end of the list.

5.2.3. Which are the top five most important factors which you have identified, for the outcomes of your project. Give the rank of 1 to the most important problem, 2 to the second most significant and so on.

Factors	tick box	rank order
Establishing technical viability	<input type="checkbox"/>	<input type="text"/>
Securing a patent	<input type="checkbox"/>	<input type="text"/>
Securing financial backing	<input type="checkbox"/>	<input type="text"/>
Managing cash flow	<input type="checkbox"/>	<input type="text"/>
Personal financial risk	<input type="checkbox"/>	<input type="text"/>
Obtaining basic resources and equipment	<input type="checkbox"/>	<input type="text"/>
Managing or working effectively with staff	<input type="checkbox"/>	<input type="text"/>
Recruiting and retaining staff working on the project	<input type="checkbox"/>	<input type="text"/>
Setting up a collaborative partnership with companies	<input type="checkbox"/>	<input type="text"/>
Retaining control of the project's development	<input type="checkbox"/>	<input type="text"/>
Controlling the development of the project	<input type="checkbox"/>	<input type="text"/>
Organisation's support for the project	<input type="checkbox"/>	<input type="text"/>

Personal problems, e.g. lack of motivation or depression etc.	<input type="text"/>	<input type="text"/>
Conflicting demands: existing business and the new project	<input type="text"/>	<input type="text"/>
Poor timing in project development	<input type="text"/>	<input type="text"/>
Establishing market demand	<input type="text"/>	<input type="text"/>
Consumer resistance to new products	<input type="text"/>	<input type="text"/>
Competing in uncertain markets	<input type="text"/>	<input type="text"/>
Economic climate	<input type="text"/>	<input type="text"/>
New legislation	<input type="text"/>	<input type="text"/>
<hr/>	<input type="text"/>	<input type="text"/>
<hr/>	<input type="text"/>	<input type="text"/>
<hr/>	<input type="text"/>	<input type="text"/>
<hr/>	<input type="text"/>	<input type="text"/>
<hr/>	<input type="text"/>	<input type="text"/>

**5.3**     *Let us look at these five most important problems in more detail. Have you managed to solve these problems or are you in the process of dealing with these problems at the moment? (NB: Stage in the development process Nb2: impact on the project and problem management)*



5.4 Could the problems which you encountered have been managed better, in your opinion? Yes ☐

No ☐

5.4.1. If yes In what way? *Probe to find out what was wrong with the approach to problem management.*

5.4.2. If no, why do you feel that the problems which you encountered could not have been managed better?

*Probe if the interviewee feels that they did all they could do to solve their problems and they were helpless beyond that in the face of the problems which they experienced. Was there no room for improvement in the approach to project management?*

*Probe if the interviewee believes that their problem management approach was successful. Encourage an evaluation of the project and problem management approach.*

Then tick and underline positive (P) and negative (N) aspects of the approach taken to project management below.

Size: number involved, constancy of membership.

☐

Membership: availability of required competence and expertise, usage of staff competence, compatibility role conflict.

☐

Leadership: weak/strong leadership, participative/autocratic leadership.

☐

Goals: objectives and goal clarity, task orientation.

☐

Project: clarity of briefing, resources i.e. time, finance, staff.

☐

Norms: guidance for operations, tolerance of disagreement.	<div></div>
Cohesiveness: shared responsibility for results, trust and support, rewards for efforts.	<div></div>
Communication: communication network flow, information transmission restrictions.	<div></div>
Inter-group relations: co-operation with other groups, petty politicking.	<div></div>
Organisation support, relevance of project to organisational strategy.	<div></div>
<div></div>	<div></div>
<div></div>	<div></div>

**5.5**      What has been the most critical incident which has affected progress in the development of this project? By critical incident, I mean either significant problems or opportunities which affected the product development project. *(N.B.: Probe to identify impact on project and management.)*

**5.6**      How effective, would you say, your approach has been to developing this product?

VERY INEFFECTIVE	INEFFECTIVE	AVERAGE	EFFECTIVE	VERY EFFECTIVE



- 5.7 In your view, *did being part of a team/would being part of a team* help you to manage the project and the problems, which you encountered during the development of the product development projects? Yes ☐
- No ☐

5.7.1. Could you explain why you hold these views?

## **SECTION 6 SUCCESS OUTCOMES: PRODUCT PERFORMANCE, SATISFACTION AND COMMERCIAL SUCCESS**

- 6.1 What measures or criteria do you use for appraising the success of a specific product or projects? Which criteria are most important for judging success? *(NB: Commercial: sales/ turnover, value on volume, profits/profit margins, costs, export sales, return on investment. Innovation. Time to market. Staff satisfaction. Product performance: pre and post market technical performance, few delays in development lack of bugs post launch, few servicing requirements and customer/user satisfaction, environmental improvement: comparisons with existing products).*

*Could we now consider the performance of the product?*

- 6.2 In your opinion, how does your product compare with other products on the market? In what way, is it a better environmental solution?

Are you able to give me any data on how the product performs?

6.3. In your view, how satisfied are the users/customers with the performance of this product?

VERY DISSATISFIED	DISSATISFIED	AVERAGE	SATISFIED	VERY SATISFIED

6.4 How satisfied are you with the product generally?

VERY DISSATISFIED	DISSATISFIED	AVERAGE	SATISFIED	VERY SATISFIED

6.5 Could further developments improve the product?

Yes

☐

No

☐

6.5.1. If yes, what changes could improve the product?



**6.6      Have there been any delays and setbacks during the development of the product?**      Yes      ☐

No      ☐

**6.6.1. If yes, What caused these delays?**

**6.6.2. If yes, What was the impact of these delays?**

**6.7      If the product has been commercialised, were there any hitches with the product after the product was launched on the market?**      Yes      ☐

No      ☐

**6.7.1. If yes, What were the hitches and how much time are they/have they taken up?**

**6.7.2. If yes, what was the impact of these hitches?**

**6.7.3. Were there problems with the servicing and maintenance of the product?**      Yes      ☐

No      ☐

**6.8      Did the product development process take more or less time than you expected or was usual?**

*Could we now consider how satisfactory the experience of working together on the product development process has been for those involved.*

**6.9      In your opinion, how satisfied are you with the experience you had of working together with the others involved in the product development process?**

VERY DISSATISFIED	DISSATISFIED	AVERAGE	SATISFIED	VERY SATISFIED

**6.10      In your view, how satisfied do you think the others involved in the product development process were with the experience you all had of working together?**

VERY DISSATISFIED	DISSATISFIED	AVERAGE	SATISFIED	VERY SATISFIED

**6.10.1. If there is satisfaction, why do you think this was a good experience for you and/or not the others involved?**

**6.10.2. If there is dissatisfaction, would you like to say why this was not a very satisfying experience for you and/or not the others?**



6.11

Would you be willing to work with the same people on new projects in the future?

Yes

☐

No

☐

6.11.1 Do you think that the others would feel the same way?

6.12. Could we consider the commercial success of the project?

6.12.1. If the project has not been commercialised. On the criteria you use, to judge commercial success mentioned earlier how commercially successful do you expect this product to be?

VERY UNSUCCESSFUL	UNSUCCESSFUL	AVERAGE	SUCCESSFUL	VERY SUCCESSFUL

*Go to question 6.15. but check to see if it appropriate to return to collect this data.*

6.12.2. If the project has been commercialised. On the criteria you use, to judge commercial success mentioned earlier, how commercially successful has this product been? (rate on scale 1-5)

VERY UNSUCCESSFUL	UNSUCCESSFUL	AVERAGE	SUCCESSFUL	VERY SUCCESSFUL

6.13 How satisfied are you with the commercial success of the product? Did the commercial results fulfil or better your expectations?

VERY DISSATISFIED	DISSATISFIED	AVERAGE	SATISFIED	VERY SATISFIED



6.14     Would you be able to provide some detailed information on some areas of commercial performance ? *I would like to emphasise that all figures will be treated in strictest confidence.*

*(NB: if figures are not to hand, collect them at the end of the interview or leave an SAE, go on to 6.15.)*

6.14.1. What has the value of total sales / turnover and profits for this project been since it was commercially launched? *(Check when sales started in year 1: Check definition of pre-tax profits, ie. difference between sales price and manufacturing cost as a percentage of sales price)*

Commercial performance	19	19	19
sales / sales turnover:			
number of units sold			
pre-tax operating profit margin			

6.14.2. Would you be able to give information on the Return On Investment?

6.14.3. Do you export this product?

Yes

☐

No

☐

If yes, what percentage of total production is exported?

☐

**6.15** To what extent, would you say that the way the product development was organised (*note if a team approach*) influenced the commercial success of the product, its technical performance and your satisfaction with the experience of working with others on the project?

Commercial success

Technical Performance

Working with others

**6.16** What were the most important factors which influenced the commercial success of the project its technical performance and your satisfaction with the experience of working with others on the project?

**6.17** *If dissatisfied with any of the success outcomes?*

Could you have approached the organisation of product development in a way which could have led to greater commercial success, technical performance and/ satisfaction with the experience of working with others on the project?

Yes

☐

No

☐

Please explain

**6.18** With my research, I am interested in multi-disciplinary team approaches to product development in companies. You have/have you come across this idea? If so, what are your views on this approach?

**6.19** General Impressions. (*N.B.: Company, people, facilities, culture*).

Thank you for your co-operation in completing this questionnaire



## Appendix 3 Postal Questionnaire And Accompanying Letter

Dear

Following a recent meeting with X about my research programme at the Centre for Technology Strategy, he suggested that you might be willing to provide further information and insight into your approach to the development and testing of the X Project. I am presently involved in a research programme which explores the different approaches adopted by companies to the management of innovative technological product or process developments which have applications in environmental areas. This focus on environmental technological projects has arisen from recent claims that there is a growing market for environmental technological products and services as well as a concern with Britain's competitiveness in EU and international markets. However, the research programme will largely contribute to a greater understanding of project management and the effectiveness of approaches, particularly team approaches to the management of innovative projects in different organisational circumstances.

I am writing to invite you to participate in this research programme and I should be grateful if you would respond to the following questions and return your response in the enclosed stamped addressed envelope. We hope that the study will provide information, which will ultimately help companies, such as yours, to approach the innovative project development process more effectively for improved commercial results. We hope to widely publish the results in journals and present it for educational purposes in new Open University courses. When the study is completed, which will be early 1995, I would be pleased to send you a report on the different approaches taken by companies to the management of new product or process developments and how effective these methods have been, in terms of different success outcomes, including commercial success and product quality and performance.

We would like to assure you that we will treat your responses with strict confidentiality and will refrain from publishing any information which you disclose, which could be used to identify yourself, your project or company. If you would like to receive the final results of this study, please mention that in your response. We are very grateful for your co-operation with our project.

I look forward to receiving your response,

Yours Sincerely,

Sally Caird (Ms)

Research Fellow



The Open  
University

Centre for Technology Strategy

Innovation • Environment • Development

APPROACHES TO  
INNOVATIVE PRODUCT / PROCESS  
DEVELOPMENTS WITH  
ENVIRONMENTAL APPLICATIONS

CONFIDENTIAL

Questionnaire  
Number

Name of Company / Division .....

Project Title .....

Name Of Respondent .....

Job title .....



**1**      *How would you describe the approach adopted by your company to product or process development in this project ?*

.....

.....

.....

.....

.....

.....

.....

**2**      **How many people in total are/have been involved in the project?**

**3**      **What expertise and competence have been contributed to the project ?**

Please tick boxes beside the competencies and expertise which are contributed by those *associated with the project*.

Please add any additional competencies and expertise which are not listed but associated with the team.

**Expertise and Competence**

1. Mechanical engineering	<input type="checkbox"/>
2. Electronics/Electrical engineering	<input type="checkbox"/>
3. Chemical engineering	<input type="checkbox"/>
4. Software engineering	<input type="checkbox"/>
5. Scientific expertise (Specify _____)	<input type="checkbox"/>
6. Industrial Design	<input type="checkbox"/>
7. Marketing	<input type="checkbox"/>
8. Sales	<input type="checkbox"/>
9. Finance	<input type="checkbox"/>
10. Production	<input type="checkbox"/>
11. Client/Customer/End user input	<input type="checkbox"/>
12. Supplier input	<input type="checkbox"/>

13. Other (Specify \_\_\_\_\_)

14. Other (Specify \_\_\_\_\_)

4 Please list the main phases of your project's development and indicate which of the areas of competence and expertise listed above contributed to each phase. Use the numbers associated with the areas of competence and expertise above as abbreviations if appropriate.

Examples of key phases in project development could include problem definition, feasibility planning and specification, design and development, manufacturing, release to client/market.

Phase	Competence/Expertise
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....

5 How effective, would you say, the approach adopted by your company to the development of this project has been?

Very Ineffective	Ineffective	Effective	Very Effective

6 Which, if any of the following problems affected the effectiveness of operations during project development?

Add any additional problems to the end of the list.

Identify the top five problems affecting your operations. Give the rank of 1 to the most important problem, 2 to the second most significant and so on.

	Tick box	Rank order
Too few/too many people involved	<div></div>	<div></div>
Lack of co-operation among those involved	<div></div>	<div></div>
Changes in personnel associated with project	<div></div>	<div></div>
Shortage of expertise	<div></div>	<div></div>
Weak leadership	<div></div>	<div></div>
Autocratic leadership	<div></div>	<div></div>
Inadequate team building	<div></div>	<div></div>
Unclear goals and briefing	<div></div>	<div></div>



Unclear procedures for operations.	<input type="text"/>	<input type="text"/>
Unfair work loads	<input type="text"/>	<input type="text"/>
Staff over-stressed and over worked	<input type="text"/>	<input type="text"/>
Poor team identity and spirit	<input type="text"/>	<input type="text"/>
Poor tolerance of disagreements.	<input type="text"/>	<input type="text"/>
Incompatibilities among members/ Unresolved conflicts	<input type="text"/>	<input type="text"/>
Poor sharing of responsibilities	<input type="text"/>	<input type="text"/>
Low trust	<input type="text"/>	<input type="text"/>
Low acceptance of accountability for results	<input type="text"/>	<input type="text"/>
Poor communication within project group	<input type="text"/>	<input type="text"/>
Poor communication with the rest of the organisation	<input type="text"/>	<input type="text"/>
Poor resources for operations, i.e. time, staff, money	<input type="text"/>	<input type="text"/>
Poor organisational rewards for project work, e.g. salary, promotion, recognition	<input type="text"/>	<input type="text"/>
Organisational resistance to the project	<input type="text"/>	<input type="text"/>
Poor senior management support	<input type="text"/>	<input type="text"/>
Others, please specify _____	<input type="text"/>	<input type="text"/>
_____	<input type="text"/>	<input type="text"/>
_____	<input type="text"/>	<input type="text"/>

7      In your opinion, how satisfied are you with the experience you had of working with other personnel associated with the development of the project?

Very Dissatisfied	Dissatisfied	Average	Satisfied	Very Satisfied

8	Would you be willing to work with the same people on new projects in the future?	Yes	<input type="text"/>
		No	<input type="text"/>

9 Which, if any, of the following factors have proved to be a problem affecting the progress of your project?

Please tick boxes beside relevant factors.  
Add any additional factors, which you regard as problems, to the end of the list.

Identify the top five most important factors problems affecting the outcomes of your project. Give the rank of 1 to the most important problem, 2 to the second most significant and so on.

Factors	tick box	rank order
Establishing technical viability	<input type="checkbox"/>	<input type="text"/>
Securing a patent	<input type="checkbox"/>	<input type="text"/>
Securing financial backing	<input type="checkbox"/>	<input type="text"/>
Managing cash flow	<input type="checkbox"/>	<input type="text"/>
Personal financial risk	<input type="checkbox"/>	<input type="text"/>
Obtaining basic resources and equipment	<input type="checkbox"/>	<input type="text"/>
Managing or working effectively with staff	<input type="checkbox"/>	<input type="text"/>
Recruiting and retaining staff working on the project	<input type="checkbox"/>	<input type="text"/>
Collaborative partnership with companies	<input type="checkbox"/>	<input type="text"/>
Retaining control of the project's development	<input type="checkbox"/>	<input type="text"/>
Controlling the development of the project	<input type="checkbox"/>	<input type="text"/>
Organisation's support for the project	<input type="checkbox"/>	<input type="text"/>
Personal problems, e.g. lack of motivation or depression etc.	<input type="checkbox"/>	<input type="text"/>
Conflicting demands: existing business and the new project	<input type="checkbox"/>	<input type="text"/>
Poor timing in project development	<input type="checkbox"/>	<input type="text"/>
Establishing market demand	<input type="checkbox"/>	<input type="text"/>
Consumer resistance to new products	<input type="checkbox"/>	<input type="text"/>
Competing in uncertain markets	<input type="checkbox"/>	<input type="text"/>
Economic climate	<input type="checkbox"/>	<input type="text"/>
New legislation	<input type="checkbox"/>	<input type="text"/>
	<input type="checkbox"/>	<input type="text"/>
	<input type="checkbox"/>	<input type="text"/>
	<input type="checkbox"/>	<input type="text"/>



10      **How would you evaluate the success of the project?** Please indicate how successful you think the project has been for the following success criteria.

**Commercial/Financial**

How commercially successful has this project been/is this project likely to be?

(For example, sales/turnover, value on volume, profits/profit margins, market penetration, export sales, keeping within budget, winning repeat business, commercial reputation, return on investment). Rate on scale.

Very unsuccessful	Unsuccessful	Average	Successful	Very successful

What commercial/financial criteria *did you* use to make your assessment?

**Innovation** In your opinion, how innovative is this project? Rate on scale.

This refers to the development of new products or processes to solve problems with commercial applications

Very Innovative	Quite Innovative	Average	Not very Innovative	Not at all Innovative

Why did you rank the project in this way?

**Product quality and performance**

In your view, how satisfied are the users/customers/clients with the performance and quality of this product/process?

Very Dissatisfied	Dissatisfied	Average	Satisfied	Very Satisfied

Satisfaction

In your opinion, how satisfied are you with your experience of the project and its outcomes?

Very Dissatisfied	Dissatisfied	Average	Satisfied	Very Satisfied

- 11
- To what extent, would you say that the *approach adopted for the development of the project* influenced the commercial success of the product/process, its technical performance and your satisfaction with the project?

.....

.....

.....

- 12
- Explain how the approach adopted by the company affected the outcomes?

.....

.....

.....

Could you have approached the development of the project in a way which could have led to greater success ?

Yes

☐

No

☐

Please explain

.....

.....

.....



**Additional Comments**

In particular, I would welcome your comments on how your company's approach to the development of the project contributed to its success.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Thank you for your co-operation in completing this questionnaire